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The ECB Monetary Policy and the Current Financial Crisis

Lena Cleanthous* **and Pany Karamanou** *

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Abstract

Our paper presents estimates of Taylor type rules for the euro area using quarterly data for the period 2004(Q4) to 2008(Q3). Unlike other studies, we employ a real-time data set using the quarterly ECB staff projections on inflation and output growth. Estimated real-time rules are also compared with a more conventional specification whereby ex-post data are employed. Our results suggest that: (i) the ECB monetary policy strategy can be represented with a simple interest-rate rule; (ii) the ECB takes into account the quarterly ECB staff projections when deciding on its monetary policy stance; (iii) the accommodative behaviour of the ECB often cited in the literature is related to differences between real-time and ex-post data; and (iv) the estimated simple interest-rate rule continues to capture the ECB monetary policy strategy during the recent financial crisis. In light of the above, we can draw three important policy conclusions. First, the ECB has a stabilising role in the economy. Second, the ECB has become rather hawkish in its monetary policy decision making, responding more to projected changes in inflation than to projected changes in the output growth gap. Finally, the ECB's response during the recent financial crisis of reducing its interest rate to 1.00% by the first half of 2009 and undertaking non-standard measures to provide support to the financial sector is shown to be equivalent to following a simple interest-rate rule based on its previous practices.

Keywords: Taylor type rules, ECB monetary policy, real-time data, financial crisis.
JEL Classification: E52, E58.

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1. Introduction

Monetary policy rules, whereby a central bank adjusts its policy instruments in response to changes in the macroeconomic environment, have become quite popular within the literature framework over the last decade. In his seminal paper, Taylor (1993) calibrated a monetary policy rule to describe the US monetary policy strategy. Since then, it has often been argued that monetary policy decisions can be described within the context of a Taylor type rule. Whilst numerous studies have focused on estimating this type of rule for the US economy, only a few have assessed the policy of the newly formed ECB, mostly due to the small time series available for the euro area.

The ECB began its operation in June 1998 following the introduction of the euro in the EMU countries. Its major objective as stated in the Treaty on European Union, Article 127, paragraph 1, is to deliver price stability and low levels of inflation[1]. Given, though, that monetary policy decisions can affect real activity in the short term, the ECB should avoid generating excessive fluctuations in output and employment if this is in line with the pursuit of its primary objective. In this respect, we can describe the monetary policy in the euro area by a Taylor type rule where interest rates respond to deviations of inflation and output from their long-term trend.

The objective of the present study is to contribute to the understanding of the ECB monetary policy strategy by inferring interest-rate rules similar to those estimated for the Fed. Given that interest rate changes affect the macroeconomy with a considerable time lag, we attempt to examine how policy decisions are related to forecasts of inflation and output and how these compare when ex-post data are used instead.

Unlike other Taylor rule studies for the euro area, we employ quarterly real-time data using the ECB staff projections on inflation and output growth available to the ECB at the time of deciding on its monetary policy. In light of the fact that the ECB Staff projections have only been publicly available since the second quarter of 2004, our sample estimation period includes only the term of the current President of the ECB,

[1] The Governing Council of the ECB aims at a year-on-year increase of the harmonised consumer price index (HICP) for the euro area below but close to 2% over the medium term.

Jean Claude Trichet, that is, between 2004(Q4) and 2008(Q3). In addition, the sample period deliberately excludes the onset of the recent financial crisis. This is crucial in our investigation of whether the ECB followed the same monetary policy strategy during the financial crisis as the one implemented in the years preceding the Lehman Brothers collapse.

Despite the short time span used and the caveats that come with it, we find that; (i) the ECB's behaviour can be represented with a simple interest-rate rule; (ii) the real-time ECB Staff projections on inflation and output are an important input to the ECB's interest rate decision making; (iii) the accommodative behaviour of the ECB suggested by some authors in the literature can be attributed to the use of ex-post rather than real-time data; and (iv) the estimated simple interest-rate rule also captures the ECB's monetary policy strategy during the crisis. From the above we can draw three important policy conclusions. First, the ECB has a stabilising role in the economy. Second, the ECB is rather hawkish when setting its monetary policy strategy. And last, the use of both standard and non-standard measures during the recent crisis was equivalent to as if it following a simple interest-rate rule based on its previous profile.

The rest of the paper is organised as follows. Section 2 introduces the theoretical background of the Taylor rule and summarises the findings of the existing literature on the euro area. Section 3 provides a description of the data set employed. Section 4 contains estimates of the ECB's interest-rate rule and out-of-sample forecasts for the ECB's monetary policy strategy during the financial crisis. Section 5 concludes.

2. Literature Review

In his seminal paper, Taylor (1993) introduced an interest-rate policy rule representing US monetary policy decisions. In the Taylor rule, the short-term real interest rate is adjusted to changes in economic conditions so as to achieve both its short-run goal of economic stabilisation and the long-run goal of price stability. The rule is expressed as:

$$\hat{\imath}_t = rr^* + \pi^* + (\beta - 1)(\pi_t - \pi^*) + \gamma(y_t - y^*)$$

$$\hat{\imath}_t = \overline{rr} + (\beta - 1)(\pi_t - \pi^*) + \gamma(y_t - y^*) \quad with \quad \overline{rr} = rr^* + \pi^* \tag{1}$$

where $\hat{\imath}_t$ refers to the Taylor rule rate in period t, rr^* is the equilibrium real interest rate, $\pi_t - \pi^*$ is the deviation of inflation in period t from its target rate π^* and $y_t - y^*$ and is the deviation of output growth in period t from its potential y^*, or output gap $\tilde{y}_t$. The equilibrium nominal interest rate $\overline{rr}$ is equal to the equilibrium real interest rate plus the target rate of inflation.

Taylor assumes that the inflation target and real equilibrium interest rates are at 2%, and that the Fed places equal weight on both inflation and output deviations from their target rate ($(\beta - 1) = \gamma = 0.5$). The rule recommends that monetary policy should be tighter whenever inflation is above its target rate or above its full employment level. The fact that the coefficient for inflation is positive and greater than 1 indicates that the rule is stabilising. That is, given that private decisions are driven by changes in the real interest rate, the nominal interest rate should increase by more than the increase in inflation to ensure an increase in the real interest rate.

Surprisingly, although there was no consensus about the size of the coefficients and no underlying econometric estimation behind it, the rule closely approximated the Federal Reserve's policy. Since then, it has been widely used to explain monetary policy in other central banks with similar monetary policy regimes, albeit with similar refinements.

First, the rule described in equation 1 has a backward-looking specification as it employs realised outcomes of inflation and output gap. Such backward-looking rules have been criticised on the grounds that, at the time of monetary policy formation, central bankers focus on expected rather than past or current behaviour of inflation and output given the lagged effects of monetary policy. Forward looking policy rules were first analysed by Clarida, Gali and Gertler (1998). The specific formulation is expressed as:

$$\hat{\imath}_{t=}\alpha + \beta\left(E[\pi_{t,k}|\Omega]_t - \pi^*\right) + \gamma(E[\tilde{y}_{t,q}|\Omega]_t)$$

$$\Rightarrow \alpha = \overline{rr} - \beta\pi^*$$

$$\Rightarrow \tilde{y}_{t,q} = y_{t,q} - y^* \qquad (2)$$

where $E[\ \dots]_t$ denotes the expectation operator, $\tilde{y}_{t,q}$ is the average output gap between period t and t+q, $\pi_{t,k}$ is the inflation rate between periods t and t+k and Ω_t is the information up to time t. The equation here is set in a forward-looking manner with interest rates adjusting to the future expectations of the inflation and output gap.

Further to the argument that forward looking rules are better representatives of the central banks' monetary policy decision making, Orphanides (2001a) argues that forward looking ex-post data cannot accurately capture the real-time dimension of a central bank decision given that the data are usually subject to significant revisions. Correct estimates could be obtained if one included only the information available at the time the decision was made.

Second, the simple Taylor rule assumes that deviations of inflation and output from their targeted rate will be immediately reflected in the short-run real interest rate. According to Clarida, Gali and Gertler (1998, 2000), however, central bankers avoid reacting too quickly to changes in the economic environment and often appear to adjust interest rates gradually towards a desired setting in the future. This is to ensure that market expectations remain well anchored. To capture this interest rate smoothing the actual interest rate is assumed to partially adjust to the target interest rate according to the equation

$$\hat{\imath}_t = (1-\rho)\overline{rr} + \rho\hat{\imath}_{t-1} + v_t \qquad (3)$$

where the parameter $\rho\epsilon[0,1]$ captures the degree of interest rate smoothing. Combining the target model (2) with the partial adjustment mechanism (3) yields:

$$\hat{\imath}_t = (1-\rho)(\alpha + \beta\big(E[\pi_{t,k}|\Omega]_t - \pi^*\big) + (1-\rho)\gamma\big(E[\tilde{y}_{t,q}|\Omega]_t\big) + \rho\hat{\imath}_{t-1} + v_t \qquad (4)$$

Table 1 summarises the findings of several papers on Taylor rule reaction functions estimated, particularly for the euro area under the assumption of partial adjustment. The results suggest that when ex-post data are used (backward looking specification) the ECB is found to have a destabilising role in the economy given the small reaction to both inflation and output growth gap movements. On average, the estimated reaction to inflation and output growth gap movements is to increase the ECB interest rate by 0.75 percentage points and 0.86 percentage points, respectively. Even though the ECB responds to a sudden increase in inflation and output gap by increasing the nominal interest rate, this increase is not enough to ensure a simultaneous increase in the real interest rate.

[Insert Table 1]

In contrast, when forward-looking data is employed, the average reaction to inflation and output growth gap movements increases to 1.92 percentage points and 1.11 percentage points, respectively. Thus the existing literature on forward looking rules suggests that the ECB has a stabilising effect both in terms of inflation and output. At the same time it tends to react strongly to variations in the inflation rate but much less to output variations. This is consistent with the ECB's primary objective of maintaining price stability in the medium term.

3. The Data

In order to shed more light on the relevance of a forward looking specification for the ECB's reaction to inflation and output gap movements, we employ quarterly real-time data for the period 2004(Q4) to 2008(Q3). Our dependent variable is chosen to be the ECB's main refinancing operations (MRO) rate, recorded at the end of each quarter. Monetary policy cannot influence the market interest rate directly but rather the ECB signals a change in the Euro Overnight Index Average (EONIA) through a change in the MRO rate. **Chart 1** shows the close relationship between the two rates, with the EONIA rate nicely tracking the path of the MRO. The last year seems to be an exception and one may argue that the fluctuations observed in the EONIA rate in 2008 reflected the onset of the financial crisis.

[Insert Chart 1]

3.1. The construction of the data set

Real-time expected inflation[2] and output growth time series for the euro area have been constructed from the ECB Staff Projection exercises. These exercises are performed on a quarterly basis and provide annual growth rate forecasts of inflation and output for the current and the year ahead. Although the ECB has established in 1999, the sample period is shorter due to the fact that the ECB didn't begin publishing its quarterly staff projections until the second quarter of 2004. To construct real-time data for every quarter of a given year, we define the expectation of inflation and output growth to be the average of the current and the year ahead forecasts[3]. Table 2 shows an example on how time series data have been constructed. The expectation for the first quarter of 2005 is defined to be the average of the 2005 and 2006 ECB staff forecasts, whilst the expectation for the last quarter of 2005 is defined to be the average of the 2006 and 2007 ECB staff forecasts[4].

[Insert Table 2]

Given the absence of a consistent output gap forecast by the ECB, we construct implied forecasts of the output growth gap by deducting an estimate of the annual potential growth rate from the forecasted GDP growth rate following Jansson and Vredin (2003) and Gorter et all (2007). The potential growth rate was set to 2.0%[5], following the ECB's reports of a potential growth for the euro area of 2 to 2.5% per annum (ECB 2001, 2002)[6].

[2] The ECB defines inflation as the year-on-year increase in the harmonised consumer price index (HICP).

[3] In the last quarter of each year, the ECB publishes staff projections on inflation and output growth for the current, one and two years ahead (Y_0, Y_1, Y_2). Given, however, that the ECB sets its monetary policy for the medium term, and that the projection for the current year is really the projection of the last quarter, the estimation of the real-time data from the December projection exercises includes the average of the two years ahead forecasts only and thus excludes the current year projections.

$$Y_T = [E(Y_t + Y_{t+1})]/2 \begin{cases} t = \tau + 1, & when\ T = 2004Q_4, 2005Q_4, 2006Q_4, 2007Q_4, 2008Q_4, 2009Q_4 \\ t = \tau, & otherwise \end{cases}$$

whereby τ = 2004, 2005, …, 2009 and T = 2004(Q4), 2005(Q1), …, 2009(Q4)

[4] See **Appendix A** and **B** for more analysis on the construction of real-time data.

[5] A limitation of using a fixed potential growth is that it only changes the point estimate of the constant from the regression estimate.

[6] In addition the Conference Board of the Global Economic Outlook 2010 and Beyond (November 2009) suggests euro area potential output growth to be, on average, 1.95% during the period 2000 – 2008.

An inflation target rate of 1.8% has also been imposed as a quantitative definition of price stability following the ECB's remit to maintain inflation below but close to 2.0% over the medium term[7].

For comparison purposes, ex-post data are also used to estimate backward looking Taylor rules. Quarterly data on ex-post HICP inflation and real GDP are obtained from Eurostat whereas the output gap is estimated as the percentage difference between realised real GDP and potential output. To obtain a measure of potential output, we apply the Hodrick-Prescott filter (with the smoothing parameter set at $\lambda = 1600$) on ex-post real GDP[8].

[Insert Chart 2]

3.2. Data analysis

A closer look at the data in **Chart 2** reveals some important differences. Over the sample period, the ECB Staff projections on inflation and real GDP are on average close to 2%. Despite the fact that actual inflation was on average above target by one half of a percentage point, expectations remained well anchored during the sample period. In addition, expected inflation seems to follow closely the ECB MRO rate[9]. This is also confirmed by the calculated correlation between the ECB interest rate with projected and ex-post inflation data (**Table 3**). The correlation coefficient between the interest rate and projected inflation is above 0.5, which indicates a strong relationship between the two variables. On the other hand, only a weak correlation is obtained with ex-post inflation, whilst a stronger correlation is obtained with ex-post rather than projected real GDP and, consequently, the output growth gap.

[Insert Table 3]

[7] For robustness purposes, the analysis was also performed using an inflation target rate of 1.9%. No significant difference was detected.

[8] Following the example of Gorter et al (2008), to calculate a reliable measure of the potential output we use quarterly data on real GDP from 1995 onwards. For robustness purposes, we have also estimated an ex-post output growth gap using the same methodology as for the real-time output growth gap. No significant differences were observed in the estimated equations of Section 4.

[9] For a comparison of real-time and ex-post data summary statistics see **Appendix C** and **D**.

As seen in **Chart 2**, the relationship between projected inflation and the ECB interest rate seems to have broken down during the period 2006(Q4) to 2007(Q2). Whereas a decrease in HICP inflation was projected during that time, a sharp increase in the ECB interest rate was recorded. This also holds when one compares ex-post inflation with the ECB rate. Looking further at the data, the fall in HICP inflation is attributed to the energy component of the HICP following the plunge observed in world oil prices at the time. The core inflation of the euro area (HICP excluding energy and food prices) on the other hand, increased dramatically during that time which could well explain the response of the ECB in raising its key interest rate given its objective to maintain price stability over the medium term.

Finally, stationarity of the series is assumed rather than tested. Although Gerlach-Kristen (2003) criticised the literature on Taylor rules for failing to account for the non-stationarity properties of the data, our sample size is too small to perform unit root tests with accurate measurement of critical values and probabilities (see **Appendix E** for a summary of the tests). A limitation of non-stationary data is that regression results may be spurious and the implied relationships not genuine. As an alternative to unit root tests, a Johansen cointegration test is applied with the trace and maximum eigenvalue test indicating, at most, one cointegrating equation for real-time data[10] (see **Appendix F**). In this respect, the foregoing regression analysis is assumed to reveal long-run relationships and OLS estimations are tested for consistency using the Engle-Granger ADF cointegration test. In addition, there is a strong argument in the literature that the data is stationary given the fact that the ECB has always followed a stable monetary regime (Gorter, et al 2008).

[10] In contrast, when the Johansen cointegration test is applied on ex-post data, no cointegrating relationship can be detected at the 5% level (see Appendix F).

4. Empirical Analysis

4.1. Simulated Taylor rule

The US monetary policy rule originally calibrated by Taylor (1993) assumes equal weights for inflation and output deviations from their respective target rates. To test whether this calibrated formula also holds for the ECB, monetary policy rules are simulated using the Taylor rule weights for ex-post and real-time data. The equilibrium nominal interest and inflation target rates are set at 2.0% and 1.8%, respectively. In contrast to the US case, under the term of Jean Claude Trichet, the Governing Council of the ECB does not seem to have responded equally to inflation and output growth gap changes, irrespective of the data sample used (Chart 3). In fact, the simulated rules consistently overestimate the ECB interest rate. In the case of the third quarter of 2008, the simulated rate overestimates the ECB rate by 317 basis points when ex-post data are employed and by 108 basis points when real-time data are used instead.

[Insert Chart 3]

4.2. Estimates of reactions functions for the euro area

Given the poor fit of the original Taylor rule to the ECB rate, we proceed with estimating a range of reaction functions for the euro area comparing the results obtained from both ex-post and real-time data. Columns (1), (3) and (5) of **Table 4** refer to the results when ex-post data are employed and columns (2), (4) and (6) to the results when real-time data are used. All equations of **Table 4** were estimated by simple OLS[11].

4.2.1. Using ex-post data

Firstly, in order to abstract from the original calibrated values of the Taylor rule, a simple Taylor fitted rule is estimated empirically for equation 1 using ex-post data

[11] For robustness purposes, the ECB staff projections are treated as endogenous variables and the best fit model in column (6) is estimated again using the Generalised Methods of Moments (GMM). As shown in **Table 5**, the GMM results do not differ significantly from the OLS results and therefore endogeneity problems do not drive our main results. However, one should be cautious when interpreting the above results as the GMM estimator may perform poorly in small samples.

providing the baseline specification against which all other estimations are compared. The outcomes of the estimated equation are presented in column (1).

The estimated weights on ex-post HICP inflation and the output gap are -0.06 and 0.56, respectively. The weight on HICP inflation is statistically insignificant and close to zero implying that the ECB did not respond to changes in inflation during the period 2004(Q4) to 2008(Q3). On the other hand, the output gap parameter, although significant, does not exceed 1. Hence, with ex-post data, the ECB is found to respond only to changes in the business cycle. Furthermore, the Engle and Granger cointegration test indicates that the residuals are non-stationary implying that the estimated relationships of the baseline specification may be spurious.

To control for the reportedly high serial correlation in the residuals of equation 1, we included a lagged interest rate as an additional explanatory variable to account for the tendency of central banks to smooth out changes in interest rates as described in the literature. The empirical estimates of the partial adjustment model (equation 4) using ex-post data are reported in column (3).

The results show that the coefficient of the lagged term is positively significant and less than unity, supporting the view of a gradual adjustment in the ECB interest rate to a desired setting following a policy shock. In comparison with the baseline equation of column (1), the ECB realised inflation parameter reduces further in value and remains insignificant, while the output gap parameter increases in value but remains well below 1. The inclusion of the lagged interest rate term may have improved the fit of the regression but nonetheless does not lower the degree of serial correlation in the errors.

In column (5), an additive dummy variable for the period 2006(Q4) – 2007(Q2)[11] is added to the partial adjustment model to account for the outlier in the residuals of the estimated equation in column (3). The coefficient on the dummy variable is positively significant which implies that during that period the ECB increased its interest rate by 154 basis points more than suggested by the level of the realised HICP inflation and output growth gap. As mentioned in Section 3, while HICP inflation fell at the time in

[11]The dummy variable takes the value of 1 for the period 2006(Q4) – 2007(Q2) and zero otherwise.

response to the sharp fall in international oil prices, core inflation (defined to be the rate of HICP inflation excluding energy and food) continued its upward trend. Consequently, the ECB appears not to have responded to this temporary exogenous shock, a response which is in line with its primary objective of maintaining price stability over the medium term. Nevertheless, the coefficient for inflation is still insignificant, albeit positive this time, while a test on the residuals of the equation cannot reject their non-stationary nature.

In general, our estimated results are in line with the existing literature on contemporaneous rules for the euro area (see **Table 1**) and suggest that when ex-post data are employed the ECB is found to respond to changes in inflation by an amount which is not enough to ensure an instantaneous increase in real short-term interest rates. As argued before, this accommodating behaviour results in a destabilising policy with respect to inflation.

[Insert Table 4]

4.2.2. Using real-time data

A general critique of the use of ex-post data for the estimation of monetary policy rules is that they may differ significantly from the data available to the policymakers at the time of forming their monetary policy strategy (Orphanides 2001a, 2001b, 2002). To acknowledge this argument, we employ real-time data from the ECB staff projections exercises as explained in Section 3.1 and estimate appropriate Taylor rules.

The results of the estimated forward-looking models differ substantially from the ones using ex-post data. Analytically, focusing on the results of the baseline specification (column (2)), the coefficients on expected HICP inflation and expected output growth gap are both significant and exceed 1, increasing to 2.07 and 1.66, respectively. This implies a hawkish response by the Governing Council of the ECB as it appears to respond more to changes in expected inflation than to changes in the output growth gap. However, a test on the residuals of the baseline equation fails to reject non-stationarity, a condition which could influence the estimated coefficients of the explanatory variables.

By adding an interest rate smoothing parameter (column (4)), the fit of the equation improves significantly. At the same time, in contrast to the ex-post partial adjustment (PA) model, an Engle and Granger cointegration test on the residuals confirms a true long-run relationship between the variables, even though the estimated results suggest a higher response to expected changes in the business cycle than to changes in expected inflation. The coefficient on the lagged interest term is again positive and large, implying that the ECB smoothes its interventions in the money market. This policy inertia may also be explained as a moderate response to perceived shocks so as to avoid responding to noise in the data (Orphanides, 2003).

Finally, the estimation of the PA model with the dummy variable (column (6)) improves the results further. Comparing ex-post versus real-time data, the response to inflation shocks increases to 2.78 while the response to the output growth gap shocks to 1.46. The estimated coefficients of the smoothing parameter and the dummy variable do not differ much from the ones obtained when using ex-post data. Overall, the model's regression fit is good and the residual auto-correlation assumptions are rejected based on the standard Breusch-Godfrey LM test. In addition, a true long-run relationship cannot be rejected based on the Engle and Granger approach to cointegration, while the Cusum of Squares tests confirm the stability of the coefficients. In light of the above, we may conclude that the PA model with the dummy variable has the best fit characteristics in representing the ECB's monetary policy and from here on it will be referred to as the best fit model.

[Insert Chart 4]

Overall, the results of the best fit model suggest that the accommodative behaviour of the ECB often implied in the literature can be explained by the use of ex-post rather than real-time data[13]. Irrespective of the Taylor rule specification, the regressions based on ex-post data point towards a destabilising policy for the ECB, whereby the reaction to inflation shocks is insufficient to ensure an increase in real short-term interest rates. In contrast, the best fit model based on real-time data, as described above, implies a stabilising role of the ECB with the expected inflation parameter being significantly

[13] This is consistent with the findings of Gorter, Jacobs and de Haan (2008) and Sauer and Sturm (2007).

above 1. At the same time, the significantly positive coefficient on the expected output growth gap indicates that the ECB follows a standard "leaning against the wind" policy, tightening monetary policy when growth is robust and vice versa. However, following the period under Jean Claude Trichet's Presidency, the ECB appears to have taken a hawkish approach in setting interest rates as the Governing Council is more likely to react to expectations of a change in inflation than to expectations of a change in the output growth gap. What is more, the significance of the dummy variable may imply that the ECB is more concerned about changes in the rate of inflation excluding energy, a parameter that is more indicative of permanent shocks within the euro area economy and more in line with the ECB's primary objective of maintaining price stability over the medium term.

4.2.3. The current financial crisis and the implied response of the ECB

A question arises as to whether the ECB has followed the previously estimated Taylor type rule to form monetary policy at the time of the financial crisis or whether it deviated from its previous practices. In this section, we use the best fit model (**Table 4**, column (6)) in conjunction with the ECB staff projections on inflation and real GDP for the period 2008(Q4) – 2009(Q4) to provide a rough benchmark of what the stance of the ECB monetary policy should have been in the current period of world economic recession given its previous profile. In **Chart 5** the historical path of the ECB MRO rate is plotted against the real-time data for inflation and real output projections with the dashed lines used to indicate the post crisis period. The ECB staff predicted a sharp fall in inflation and output during the end of 2008 and the first half of 2009 and a slight improvement thereafter. The path of the MRO rate confirms our findings that the Governing Council of the ECB is more likely to respond to expected changes in inflation than to expected movements of the business cycle. In particular, despite expectations of significant negative growth in 2009, the interest rate was lowered by a much lesser degree in response to a stable and positive inflation profile.

[Insert Chart 5]

Using the estimated best fit policy rule and the forecasts of inflation and output, the response of the ECB monetary policy is projected five quarters ahead. The recommended policy rate is plotted in **Chart 6**, whilst the forecasted values of the ECB MRO rate are presented in **Table 4** under column (6)[12].

By the first half of 2009, the actual ECB interest rate was decreased by 325 basis points from 4.25% in the third quarter of 2008 to 1.00%, a rate close to the 0.90% rate predicted by the estimated Taylor rule. Although actual and implied interest rates coincide more or less in value at the end of the first half of the year, the fall in the MRO rate should have been smoother based on the ECB past behaviour. Of course, given the profound effect of the crisis on the real economy, it is generally recognised that tough and on the spot decisions were mostly needed at the time. For the second half of 2009, the fitted ECB rate is close to the zero lower bound. In contrast, the ECB left its MRO rate unchanged at 1.00% during the last two quarters of the year and, instead, implemented a broad set of non-standard measures to enhance credit support and to ensure the maintenance of price stability over the medium term. Our findings thus leave scope for further research on these unconventional non-standard measures to see whether they have been enough to counterbalance the monetary policy shortfall arising from a higher ECB rate than the one suggested by the ECB's fitted Taylor type rule.

[Insert Chart 6]

In light of the above, we employ a very simple way to measure the effect of the unconventional measures by looking at the estimated relationship between the MRO rate and the EONIA rate.

[Insert Table 6]

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[12] For comparison purposes, out-of-sample forecasts were also performed using ex-post data on HICP inflation and real GDP, the results of which are presented in **Table 4** under column (5). If the ECB was assumed to react on changes to ex-post data then the recommended decrease in the MRO rate should have been constrained to just 120 basis points by the end of 2009. Clearly then, it would be considered safe to assume that, just as the evidence on its past behaviour suggests, the ECB did not rely on past data information to form its monetary policy during the recent crisis period.

In particular, since changes in the MRO are expected to be firstly transmitted to changes in the EONIA, we estimate a simple OLS regression between the EONIA and the MRO rate for the period 2004(Q4) – 2009(Q4) (**Table 6,** column (8)) of the form

$$eonia_t = \alpha + \beta(MRO)_t + e_t \quad (5)$$

where β is estimated at 1.13 verifying the one to one relationship between the two rates, as seen in **Chart 7**. From the same graph, it is easy to see that this relationship broke down after the second quarter of 2009 with the gap between the two rates averaging approximately 70 basis points. This is also easy to capture in equation 5 by including a dummy variable that takes the value of 1 for the period 2009(Q2) – 2009(Q4) and zero otherwise (**Table 6,** column (9)). One could assume that the decrease in the EONIA rate over and above the decrease suggested by the MRO rate may be attributed to the non-standard measures.

[Insert Chart 7]

The next obvious question is what level of the MRO would have induced the observed fall in the EONIA rate during the crisis. From the estimated equation 5 this can be easily shown to imply a further decrease in the MRO rate of approximated 70 basis points. In other words, had no unconventional measures been adopted, the ECB rate** in **Chart 6** would refer to the MRO rate that would be necessary to induce an equivalent change in the EONIA rate at the end of 2009.

As stated in the October 2010 ECB *Monthly Bulletin*, "the strict separation between the formulation and implementation of monetary policy as enshrined in the 'separation principle'[13] was temporarily loosened". This implies that, despite the fact that the ECB's non-standard measures were taken over and above the standard monetary policy measures in order to ensure the smooth functioning of the monetary policy transmission mechanism, they also indirectly influenced the whole spectrum of money market instruments at different maturities. In this respect, it seems that the effect

[13] The separation principle refers to the strict dividing line that the ECB keeps between monetary policy decisions and policy implementation through monetary policy operations. For further analysis, see ECB *Monthly Bulletin,* October 2010.

of the unconventional measures on the EONIA rate is equivalent to a reduction of the MRO rate from 1.00% to 0.30% by the end of 2009, a rate which is close to the zero lower bound suggested by the ECB's own rule.

5. Concluding remarks and policy implications

In this paper we estimated Taylor-type rules for the euro area using quarterly real-time data for the period 2004(Q4) to 2008(Q3). The sample period covers the term of the current President of the ECB Jean Claude Trichet up until the beginning of the latest global economic crisis. Unlike other studies, we use real-time expectations utilising the quarterly ECB staff projections available at the time of formatting monetary policy decisions. Our results suggest that the ECB's monetary policy framework can be better understood when a relationship between the ECB MRO rate and expected inflation and output is assumed. Such Taylor type rules are compared with a more conventional specification whereby the MRO rate is related to ex-post inflation and output data.

Based on our real-time estimates, we can draw three important economic policy conclusions. First, the ECB is found to have a stabilising role in the economy and only under the ex-post data model specification is the ECB found to exhibit an accommodating behaviour. Consequently, we show that the implied destabilising policy of the ECB, often cited in the literature, is due to the lack of a real-time forward-looking perspective when estimating Taylor rules.

Second, the reaction of the ECB is stronger for expected movements in inflation than for output implying that, under President Jean Claude Trichet, the ECB's Governing Council is hawkish when setting interest rates.

The third important policy conclusion that one can draw from our results is that the financial crisis has not been an exception for the ECB. Based on out-of-sample forecasts for five quarters ahead, if the ECB were to follow its own rule it should have reduced its interest rate to the zero lower bound by the second half of 2009. Instead, the

ECB maintained its short-term rate constant at 1.00% during that time and embarked on a series of non-standard measures to provide support to the financial sector in general.

A final remark is whether these quantitative easing measures have been enough to counterbalance the fact that interest rates remained above this zero threshold level during the current crisis. Using a very simplistic assumption that the break found in the relationship between the EONIA and the MRO rate during the financial crisis could be attributed to the non-standard measures of the ECB, we find the effect of such quantitative easing on the EONIA rate to be equivalent to a decrease of the ECB rate by 70 basis points to 0.30% by the end of the year, a level close to the one suggested by its Taylor type rule. A first analysis on the matter thus implies that the ECB's response to the crisis was equivalent to following a simple interest-rate rule as suggested by its past behaviour, even though the primary goal of these non-standard measures was to support the transmission mechanism of monetary policy in a context of dysfunctional markets.

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Chart 1: ECB's Main Refinancing Operations (MRO) rate vs EONIA rate

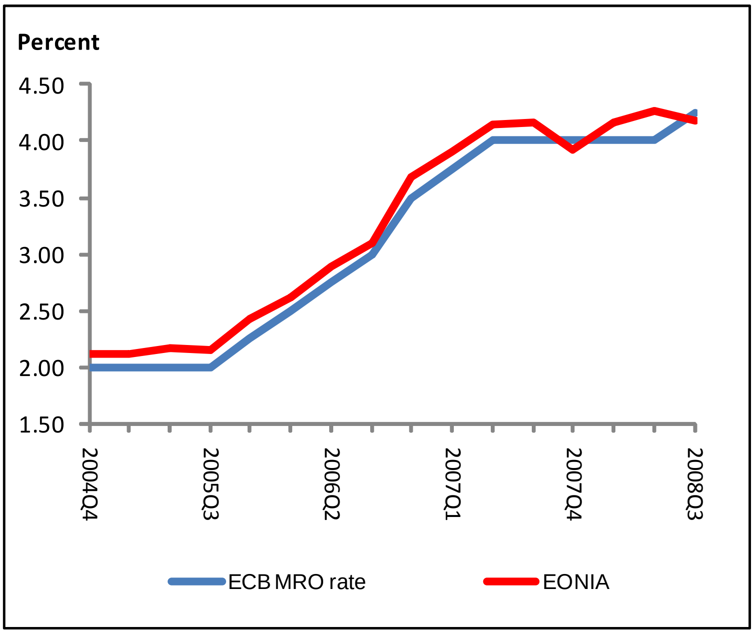
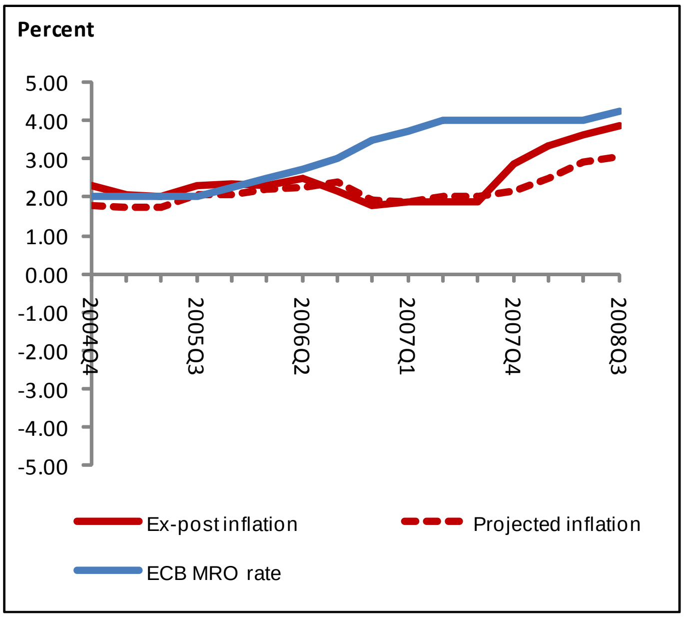


Chart 2: Comparison between ex-post data and real-time data

HICP inflation



Real GDP

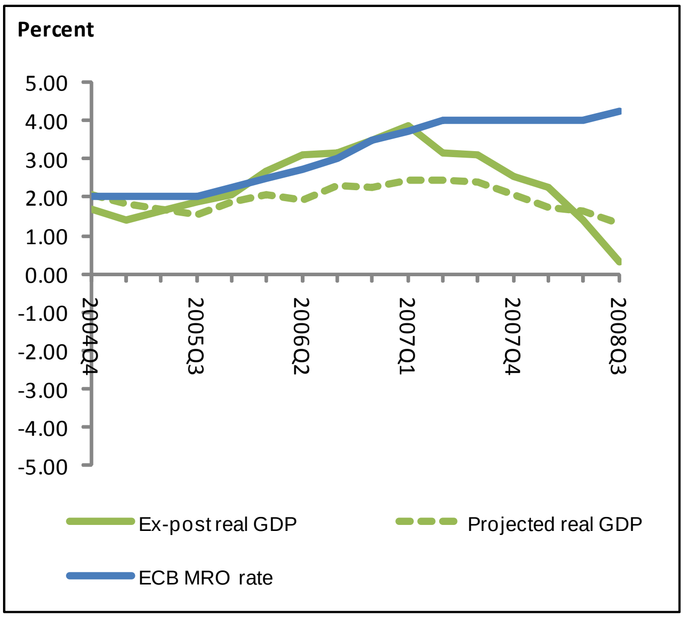
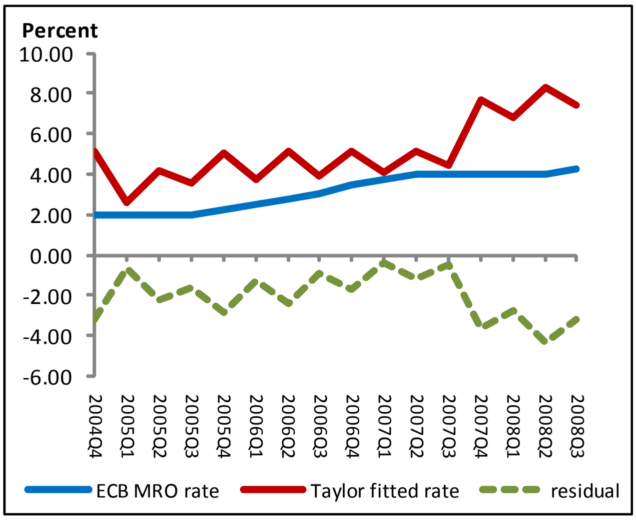


Chart 3: Comparison of the ECB MRO rate and the original Taylor type fitted rate

Ex -post data



Real-time data

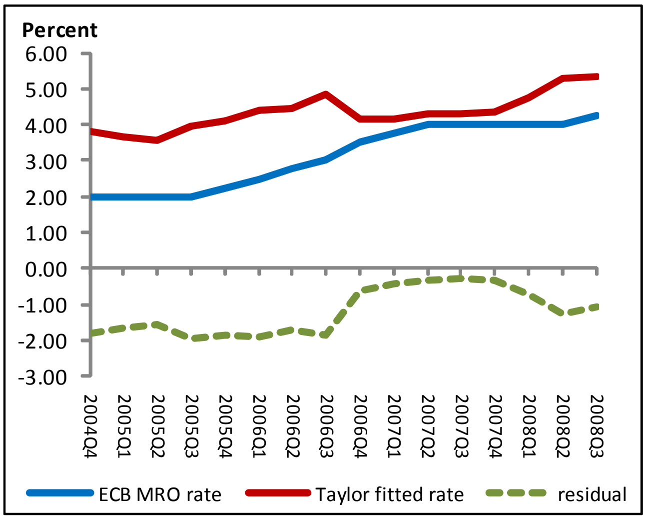
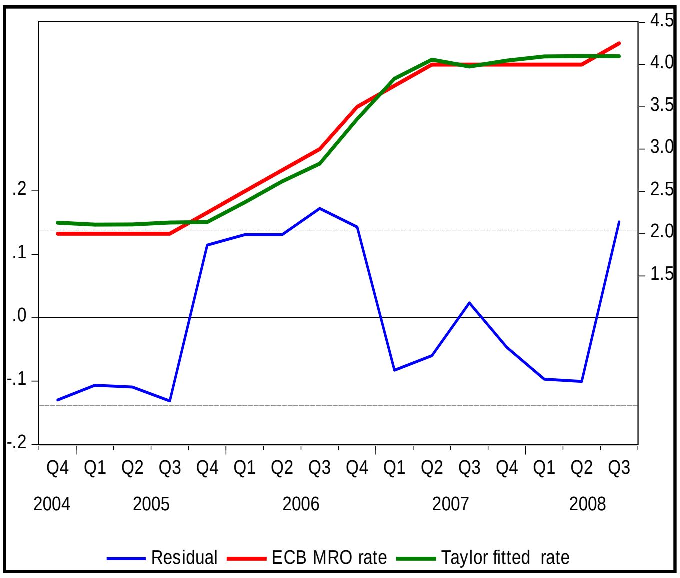


Chart 4: A comparison of the fit of the Partial Adjustment equation with dummy variable (columns (5), (6)) using ex-post and real-time data

$$\hat{\imath}_t = (1-\rho)(\alpha + \beta\left(E[\pi_{t,k}|\Omega]_t - \pi^*\right) + \gamma\left(E[\tilde{y}_{t,q}|\Omega]_t\right) + \rho\hat{\imath}_{t-1} + \theta dum_{06_{q4}-07q2} + v_t$$

Ex-post data



Real-time data

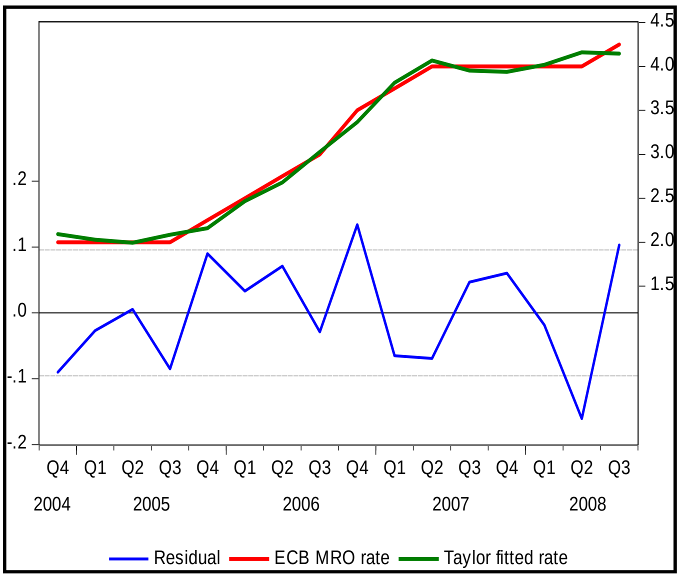


Chart 5: ECB MRO rate and ECB staff projections during the period 2008(Q4) – 2009(Q4)

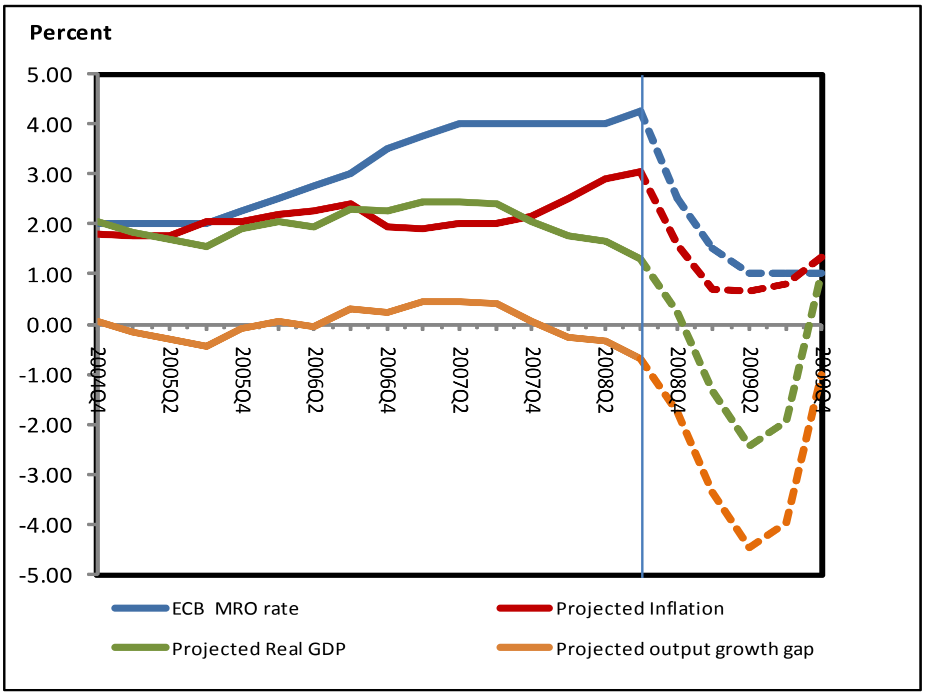


Chart 6: Expected and actual monetary policy response of the ECB

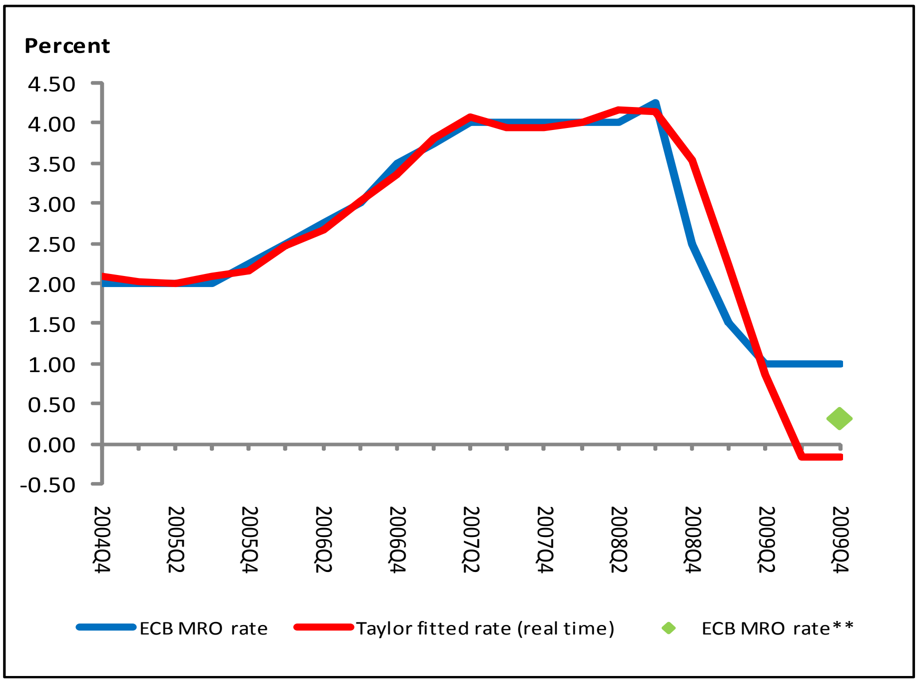


Chart 7: Graphical presentation of the fit of the estimated equation 5 (Table 6, column (8))

$$eonia_t = \alpha + \beta(MRO)_t + e_t$$

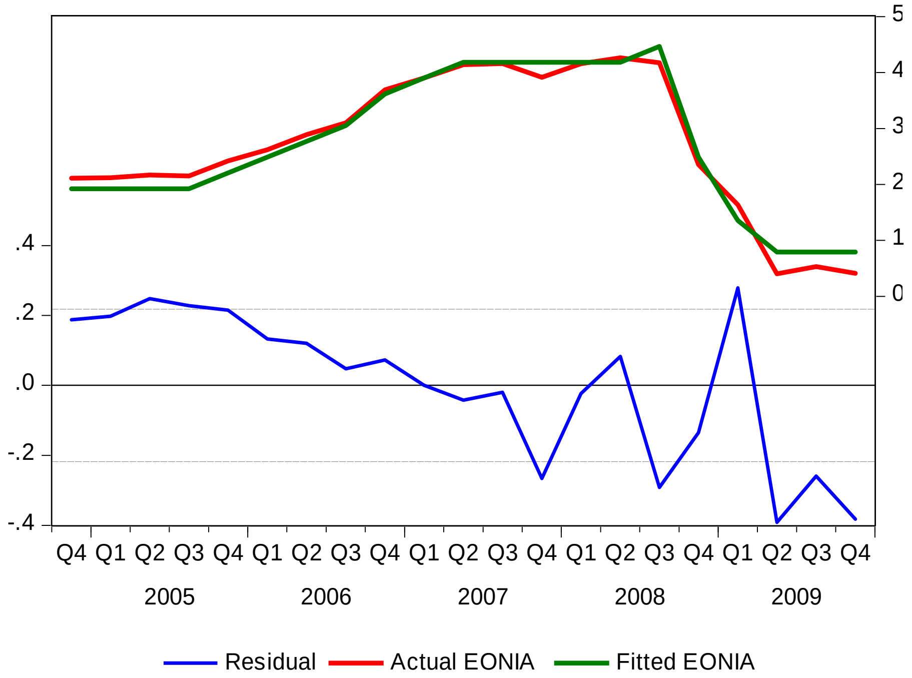


Table 1: Summary of the literature on Taylor rule estimations for the euro area

Papers	Type of rule	Estimation procedure	Sample Data	Coefficients			
				α	β	γ	ρ
Gerlach - Kristen (2003)	Backward looking	NLS	1988 (Q1) - 2002(Q2)	-1.23	2.73	1.44	0.88
Surico (2003)	Backward looking	GMM	1997(M7) - 2002(M10)	3.77	0.77	0.47	0.77
Ullrich (2003)	Backward looking	TSLS	1999(M1) - 2002(M8)	2.96	0.25	0.63	0.19
Fourcans and Vranceanu (2004)	Backward looking	GMM	1999(M4) - 2003(M10)	0.18	0.84	0.32	0.90
Sauer and Sturm (2007)	Backward looking	NLS	1991(M1) - 2003(M10)	4.81	-0.84	1.45	0.94
Fourcans and Vranceanu (2004)	Forward looking	GMM	1999(M4) - 2003(M10)	-0.38	2.8	0.19	0.84
Gerdesmeier and Roffia (2004)	Forward looking / SPF forecasts	GMM	1999(M1) - 2003(M6)	-0.84	2.91	2.02	0.67
Hayo and Hofmann (2005)	Forward looking	GMM	1999(M1) - 2003(M1)	0.32	1.48	0.6	0.85
Cobham (2005)	Forward looking	TSLS	1999(Q2) - 2005(Q1)	0.35	0.49	0.38	0.41
Sauer and Sturm (2007)	Forward looking/ survey data	NLS	1991(M1) - 2003(M10)	0.13	1.85	0.59	0.87
Gorter, Jacobs and de Haan (2008)	Forward looking / Consesus data	NLS	1997(M1) - 2006(M12)	3.66	1.67	1.65	0.89
Markov (2010)	Forward looking / SPF forecasts	GMM	2000(Q1) - 2009(Q4)	-0.06	2.26	2.32	0.96

Table 2: Example of projected real-time data series construction

	2004	2005	2006	2007	2008	2009	2010	2011
2004(Q4)	τ	τ+1	τ+2					
2005(Q1)		τ	τ+1					
2005(Q2)		τ	τ+1					
2005(Q3)		τ	τ+1					
2005(Q4)		τ	τ+1	τ+2				
2006(Q1)			τ	τ+1				
2006(Q2)			τ	τ+1				
2006(Q3)			τ	τ+1				
2006(Q4)			τ	τ+1	τ+2			
2007(Q1)				τ	τ+1			
2007(Q2)				τ	τ+1			
2007(Q3)				τ	τ+1			
2007(Q4)				τ	τ+1	τ+2		
2008(Q1)					τ	τ+1		
2008(Q2)					τ	τ+1		
2008(Q3)					τ	τ+1		
2008(Q4)					τ	τ+1	τ+2	
2009(Q1)						τ	τ+1	
2009(Q2)						τ	τ+1	
2009(Q3)						τ	τ+1	
2009(Q4)						τ	τ+1	τ+2

Table 3: Correlation between ECB MRO rate with ex-post and real-time data

Ex-post data

	ECB MRO rate
ECB MRO rate	1.000
Ex-post Inflation	0.413
Ex-post Real GDP	0.310
Ex-post Output gap	0.974

Real-time data

	ECB MRO rate
ECB MRO rate	1.000
Projected Inflation	0.563
Projected Real GDP	0.186
Projected Output growth gap	0.186

Table 4: Estimated Taylor type rules, ex-post vs. real-time data; sample period: 2004(Q4) – 2008(Q3)

	Baseline		PA		PA with dummy/ Best Fit	
	Ex-post	Real-time	Ex-post	Real-time	Ex-post	Real-time
Coefficient	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Obs	*16*	*16*	*16*	*16*	*16*	*16*
α	2.85* (0.234)	-1.32* (1.025)	5.11 (0.717)	-2.59 (0.256)	2.12 (0.626)	-2.46*** (0.173)
β	-0.06 (0.098)	2.07* (0.470)	-0.62 (0.075)	3.27*** (0.164)	0.58 (0.086)	2.78* (0.112)
γ	0.56* (0.040)	1.66* (0.529)	0.67 (0.152)	3.81** (0.154)	0.26 (0.130)	1.46*** (0.110)
ρ	–	–	0.87* (0.275)	0.90* (0.062)	0.89* (0.231)	0.85* (0.043)
θ	–	–	–	–	1.54** (0.068)	1.11* (0.041)
π*	1.80	1.80	1.80	1.80	1.80	1.80
rr¯	0.95	0.60	2.20	1.49	1.37	0.74
r*	2.75	2.40	4.00	3.29	3.17	2.54
R₂¯	0.941	0.552	0.965	0.974	0.976	0.989
RMSE	0.196	0.540	0.144	0.124	0.116	0.078
			Out of sample Forecasts			
i^f ***2008(4)***	–	–	–	–	4.16	3.54
i^f ***2009(1)***	–	–	–	–	3.95	2.23
i^f ***2009(2)***	–	–	–	–	3.70	0.85
i^f ***2009(3)***	–	–	–	–	3.45	-0.15
i^f ***2009(4)***	–	–	–	–	3.29	-0.16

*Notes: * significant at the 1% level, ** significant at the 5% level, ***significant at the 10% level; standard errors in parentheses*

Baseline: **(1)** $\hat{\imath}_t = \alpha + \beta\pi_t + \gamma(\tilde{y}_t) + \varepsilon_t$,

(2) $\hat{\imath}_{t=}\alpha + \beta\left(E[\pi_{t,k}|\Omega]_t\right) + \gamma\left(E[\tilde{y}_{t,q}|\Omega]_t\right) + \varepsilon_t$

PA: **(3)** $\hat{\imath}_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(\tilde{y}_t) + \rho\hat{\imath}_{t-1} + \varepsilon_t$,

(4) $\hat{\imath}_t = (1-\rho)(\alpha + \beta\left(E[\pi_{t,k}|\Omega]_t - \pi^*\right) + \gamma\left(E[\tilde{y}_{t,q}|\Omega]_t\right) + \rho\hat{\imath}_{t-1} + \theta dum_{06_{q4}-07_{q2}} + v_t$

Best Fit: **(5)** $\hat{\imath}_t = (1-\rho)\alpha + (1-\rho)\beta\pi_t + (1-\rho)\gamma(\tilde{y}_t) + \rho\hat{\imath}_{t-1} + \theta dum_{06_{q4}-07_{q2}} + \varepsilon_t$

(6) $\hat{\imath}_t = (1-\rho)(\alpha + \beta\left(E[\pi_{t,k}|\Omega]_t - \pi^*\right) + \gamma\left(E[\tilde{y}_{t,q}|\Omega]_t\right) + \rho\hat{\imath}_{t-1} + \theta dum_{06_{q4}-07_{q2}} + v_t$

Table 5: Estimation of partial adjustment model with dummy variable using OLS and GMM real-time data

	Best Fit model	
	OLS (real-time)	GMM (real-time)
Coefficient	**(6)**	**(7)**
Obs	*16*	*14*
α	-2.46*** (0.173)	-2.66* (0.103)
β	2.78* (0.112)	2.88* (0.050)
γ	1.46*** (0.110)	1.79* (0.037)
ρ	0.85* (0.043)	0.83* (0.017)
θ	1.11* (0.041)	1.80* (0.065)
π*	1.80	1.80
rr¯	0.74	0.72
r*	2.54	2.52
R 2¯	0.989	0.984
RMSE	0.078	0.082

*Notes: * significant at the 1% level, ** significant at the 5% level, ***significant at the 10% level; standard errors in parentheses*

Best Fit: (6), (7) $\hat{\imath}_t = (1-\rho)(\alpha + \beta(E[\pi_{t,k}|\Omega]_t - \pi^*) + \gamma(E[\tilde{y}_{t,q}|\Omega]_t) + \rho\hat{\imath}_{t-1} + \theta dum_{06_{q4}-07_{q2}} + v_t$

Table 6: OLS estimation results of the relationship between the EONIA and the MRO rates

Coefficient	**(8)**	**(9)**
Sample period	*2004(4) - 2009(4)*	*2004(4) - 2009(4)*
Obs	*21*	*21*
α	-0.34** (0.127)	0.140 (0.085)
β	1.13* (0.044)	0.99* (0.027)
δ	---	-0.68* (0.085)
$\bar{R}^2$	0.971	0.993
RMSE	0.207	0.097

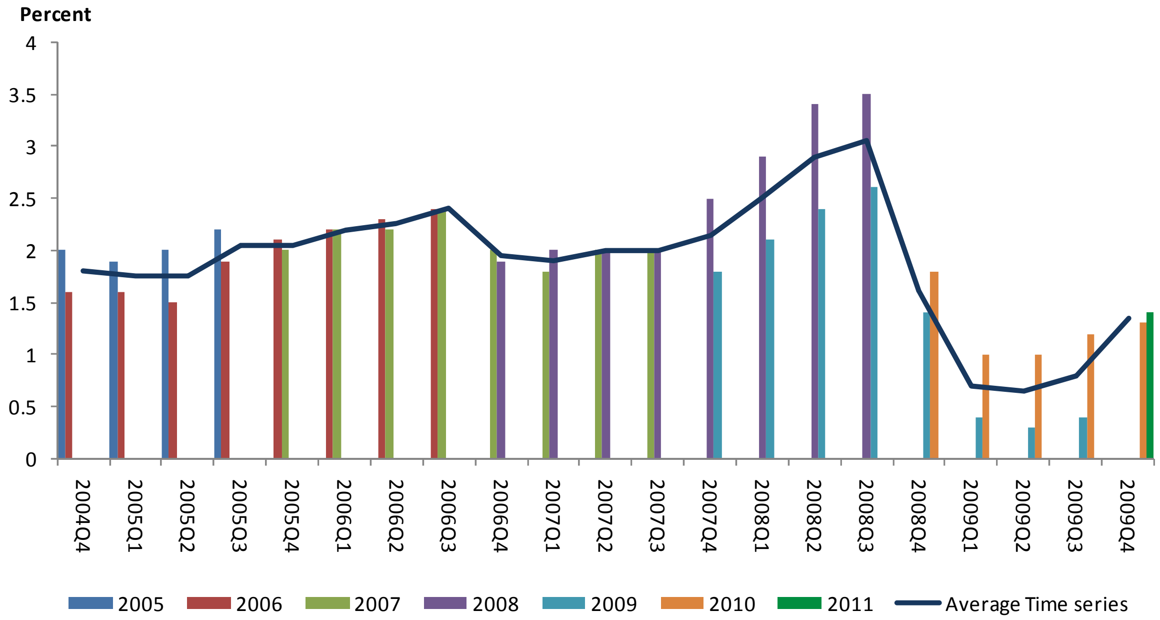
*Notes: * significant at the 1% level, ** significant at the 5% level, ***significant at the 10% level; standard errors in parentheses*

(8) $eonia_t = \alpha + \beta(MRO)_t + e_t$

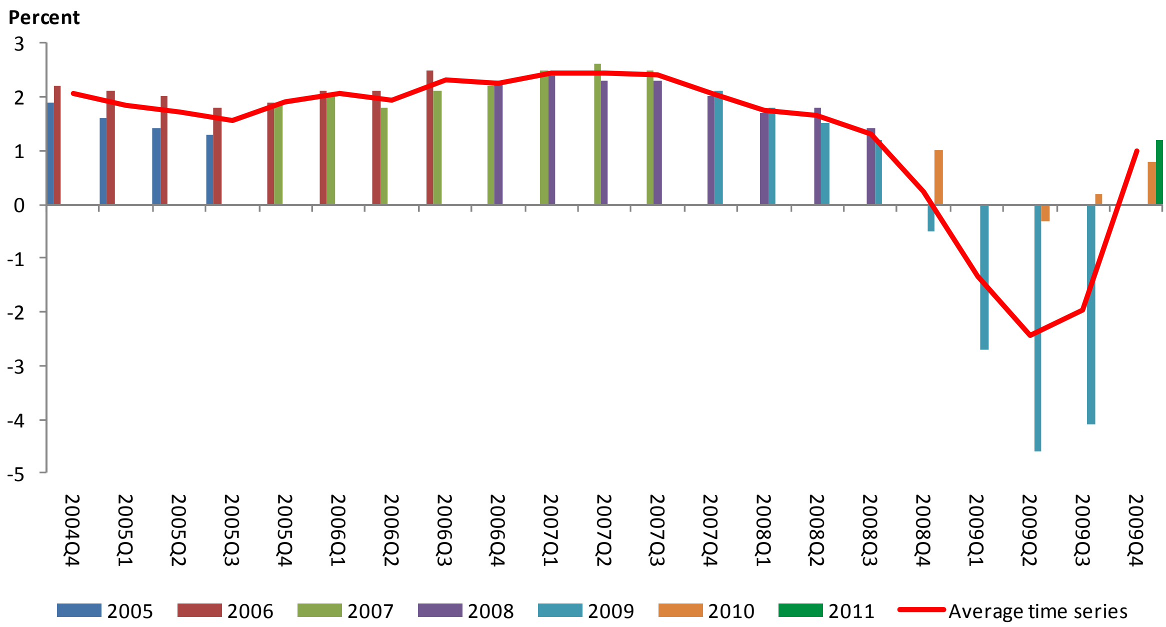
(9) $eonia_t = \alpha + \beta(MRO)_t + \delta dum_{break09_{q2}} + e_t$

Appendix

A. ECB Quarterly Staff projections of HICP inflation, 2004(Q4)-2009(Q4)



B. ECB Quarterly Staff projections of real GDP, 2004(Q4)-2009(Q4)



C. Summary Statistics on projected real-time data

	$\hat{i}_t$	$E[\pi_{t,2}]$	$E[\tilde{y}_{t,2}]$	$E[y_{t,2}]$	y^*
Obs	16	16	16	16	16
Mean	3.13	2.17	-0.02	1.98	2.00
Median	3.25	2.05	0.00	2.00	2.00
Maximum	4.25	3.05	0.45	2.45	2.00
Minimum	2.00	1.75	-0.70	1.30	2.00
Std. Dev.	0.89	0.38	0.34	0.34	0.00
Jarque-Bera	1.95	3.34	0.52	0.52	---
Probability	0.38	0.19	0.77	0.77	---

D. Summary Statistics on ex-post data

	π_t	$\tilde{y}_t$	y_t	y^*
Obs	16	16	16	16
Mean	2.45	0.75	2.37	1.49
Median	2.33	0.69	2.29	1.65
Maximum	3.85	3.21	3.57	1.95
Minimum	1.79	-1.34	0.94	0.60
Std. Dev.	0.64	1.59	0.80	0.46
Jarque-Bera	3.13	1.61	0.65	1.83
Probability	0.21	0.45	0.72	0.40

E. Summary of unit root tests

	ADF test		PP test	
	Constant	Constant + Trend	Constant	Constant + Trend
ECB rate	-0.499 (0.87)	-3.692 (0.06)	-0.273 (0.91)	-1.866 (0.63)
Projected Inflation	0.326 (0.97)	-0.969 (0.92)	0.063 (0.95)	-1.23 (0.87)
Projected Real GDP	-0.461 (0.86)	-0.243 (0.98)	-0.998 (0.72)	-0.694 (0.96)
Projected Output growth gap	-0.461 (0.88)	-0.243 (0.98)	-0.998 (0.72)	-0.694 (0.96)
Ex-post Inflation	-4.787 (0.00)	-4.279 (0.02)	-0.019 (0.94)	-0.523 (0.97)
Ex-post Real GDP	-2.312 (0.18)	0.174 (0.99)	-1.587 (0.47)	-1.352 (0.83)
Ex-post Output gap	-0.673 (0.83)	-1.491 (0.79)	-0.716 (0.82)	-1.491 (0.79)

Note: MacKinnon (1996) one sided p-values in parentheses. However, bear in mind that probabilities and critical values are calculated for 20 observations and may thus not be accurate for a sample size of 14

F. Johansen Cointegration Test on ex-post and real-time data

Series: MRO rate, ex-post HICP and ex-post output gap

Sample: 2004Q4 2008Q3
Trend assumption: Linear deterministic trend (restricted)
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value at 0.05	Prob.**
None	0.733	40.684	42.915	0.082
At most 1	0.527	19.539	25.872	0.250
At most 2	0.376	7.556	12.518	0.290

Trace test indicates no cointegration at the 0.05 level
** denotes rejection of the hypothesis at the 0.05 level*
***MacKinnon-Haug-Michelis (1999) p-values*

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	Critical Value at 0.05	Prob.**
None	0.733	21.144	25.823	0.184
At most 1	0.527	11.983	19.387	0.417
At most 2	0.376	7.556	12.518	0.290

Max-eigenvalue test indicates no cointegration at the 0.05 level
** denotes rejection of the hypothesis at the 0.05 level*
***MacKinnon-Haug-Michelis (1999) p-values*

Series: MRO rate, real-time HICP and real-time output growth gap

Sample: 2004Q4 2008Q3
Trend assumption: Linear deterministic trend (restricted)
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	Critical Value at 0.05	Prob.**
None *	0.802	45.338	42.915	0.028
At most 1	0.537	19.455	25.872	0.255
At most 2	0.360	7.144	12.518	0.330

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
** denotes rejection of the hypothesis at the 0.05 level*
***MacKinnon-Haug-Michelis (1999) p-values*

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	Critical Value at 0.05	Prob.**
None *	0.802	25.884	25.823	0.049
At most 1	0.537	12.311	19.387	0.387
At most 2	0.360	7.144	12.518	0.330

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
** denotes rejection of the hypothesis at the 0.05 level*
***MacKinnon-Haug-Michelis (1999) p-values*