Taylor rules for the ECB using consensus data
Taylor rules for the ECB using consensus data

Janko Gorter, Jan Jacobs and Jakob de Haan*

* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.
Taylor Rules for the ECB using Consensus Data

Janko Gorter*, Jan Jacobs** and Jakob de Haan***

* De Nederlandsche Bank, The Netherlands
** Faculty of Economics and Business, University of Groningen, The Netherlands
*** Faculty of Economics and Business, University of Groningen and CESifo Munich, Germany

6 December 2007

Abstract
We estimate Taylor rules for the euro area using Consensus expectations for inflation and output growth and we compare these estimates with more conventional specifications in which actual outcomes are used. According to the model with Consensus data, the ECB takes expected inflation and expected output growth into account in setting interest rates, while in the more conventional model specification the coefficient of inflation is not significantly different from zero. Only when using survey data we find that the ECB’s policy has been stabilizing. Finally, using a framework suggested by English et al. (2003), we find support for both policy inertia and serially correlated errors in ECB Taylor rules.

Key words: Taylor rule, ECB, real-time data, policy inertia, serial correlation

JEL classification: C22, E52

Corresponding author: Jakob de Haan, Faculty of Economics and Business, University of Groningen, PO Box 800, 9700 AV Groningen, The Netherlands, Tel. 31-(0)50-3633706; Fax 31-(0)50-3633720; email: jakob.de.haan@rug.nl.

Acknowledgements
We like to thank two anonymous referees and Nils Gottfries, Jan-Egbert Sturm and participants at the IEE seminar at the University of Groningen for their very helpful comments on a previous version of the paper. The views expressed in the paper do not necessarily reflect the views of De Nederlandsche Bank.
1. Introduction

Taylor (1993) suggested that a simple monetary policy rule relating the nominal short-term interest rate to inflation and the output gap accurately describes US monetary policy over the period 1987-1992. The Taylor rule seems a reasonable description of central bank behaviour in other countries as well. However, as Svensson (2003) has shown, even if the ultimate objective of monetary policy is to stabilize inflation and output, a simple Taylor rule will not be optimal in a reasonable macroeconomic model. Interest rate changes affect inflation and output with a variable and sizable lag. Therefore, monetary policy has to be forward-looking, i.e., it should be based on expected inflation and output. Realized outcomes for inflation and output enter the optimal decision rule if they help to predict future inflation and output, but so will any other variable that provides information concerning future inflation and output. Consequently, monetary policy will, in general, be more complicated than the simple Taylor rule suggests.

The foregoing analysis leads to the question of whether monetary policy can be better understood by examining how policy decisions are related to forecasts for inflation and output. In this paper we estimate Taylor rules for the euro area, using the 1997.1-2006.12 period. In contrast to most previous research, we employ expectations for inflation and output growth in our Taylor rule model for the ECB.¹ We compare these estimates with a more conventional specification in which outcomes for inflation and output are used. According to the model estimated with forward-looking data, the ECB takes expected inflation and expected output growth into account in setting interest rates, while in the more conventional model specification the coefficient of inflation is not significantly different from zero.

Most Taylor rule studies include the lagged interest rate as explanatory variable in the model (see, e.g., Clarida et al., 1998), assuming that central banks dislike jumps in the short-term interest rate and prefer interest rate smoothing. However, Rudebusch (2002) argues that the significance of the lagged interest rate may be caused by omitted shocks in the estimated policy rule, like financial crises, that will give rise to serially correlated errors. We employ a framework suggested by English et al. (2003) that allows distinguishing between policy inertia and

serially correlated errors. Our estimates lend support to both policy inertia and serially correlated errors in ECB Taylor rules.

The remainder of the paper is structured as follows. Following Svensson (2003), the next section provides a brief theoretical background. Section 3 outlines our framework and section 4 discusses the variables used in our estimations. Section 5 contains estimates of several Taylor rule models. Finally, Section 6 offers some concluding comments.

2. Theoretical background
In this section we give a motivation for our Taylor rule with forward-looking data, following Svensson (2003). The purpose of this section is to provide some intuition as to why expectations concerning inflation and output should play a role in describing monetary policy.\(^2\)

Consider an intertemporal loss function \( L \) to be minimized in each period \( t \), \( t = \ldots, -1, 0, 1, \ldots \), consisting of the expected sum of discounted current and future losses,

\[
E \left[ (1 - \delta) \sum_{\tau=0}^{\infty} \delta^\tau L_{t+\tau} | I_t, z' \right],
\]

(1)

where \( E[I_t, z'] \) denotes rational expectations conditional on the central bank’s information, \( I_t \), in period \( t \) about the state of the economy and the transmission mechanism of monetary policy, and the bank’s “judgment”, \( z' \), while \( \delta (0 < \delta < 1) \) is the discount factor. The period loss is a weighted sum of the squared inflation gap (\( \pi_t - \pi^* \) where \( \pi^* \) is the inflation objective) and the squared output gap (\( x_t \)),

\[
L_t = \frac{1}{2} \left[ (\pi_t - \pi^*)^2 + \psi x_t^2 \right],
\]

(2)

where \( \psi > 0 \) is a given weight on output-gap stabilization relative to inflation stabilization. The monetary-policy problem for the central bank is then to set its interest rate \( i_t \) each period so as to minimize the intertemporal loss function,

\(^2\) We thank the editor for this suggestion. The model does not take interest rate smoothing into account, but our empirical work does.
subject to the central bank’s information about the state of the economy and its judgment.

As in Svensson (2003), we add the following forward-looking model of the transmission mechanism.\(^3\) The aggregate-supply and aggregate-demand equations are

\[
\pi_{t+1} - \pi = \delta \left( \pi_{t+2} - \pi \right) + \alpha_x x_{t+2} + \alpha_z z_{t+1} + e_{t+1}
\]

(3)

\[
x_{t+1} = x_{t+2} - \beta_r \left( r^*_{t+1} - \pi_{t+2} - r^* \right) + \eta_{t+1},
\]

(4)

where \( \pi = E[\pi_t] \) is the average inflation rate, \( e_{t+1} \) and \( \eta_{t+1} \) are iid “cost-push” and “excess-demand” shocks, and \( r^* \) is an exogenous Wicksellian natural interest rate corresponding to a “neutral” real interest rate consistent with a zero output gap in the absence of deviations. In this set-up, the optimal interest rate depends on the central bank’s expectations about \( z \).

Taylor (1993) proposed the following rule:

\[
\hat{i}_t = r^* + \pi^* + k_\pi (\pi_t - \pi^*) + k_x x_t ,
\]

(5)

where \( \hat{i}_t \) is referred to as the Taylor-rule rate in period \( t \), \( r^* \) is the equilibrium real interest rate, \( \pi_t - \pi^* \) is the deviation of inflation in period from the inflation target \( \pi^* \) and \( x_t \) is the output gap in period \( t \). Taylor suggested the following values for the coefficients: \( r^* = 2 \), \( \pi^* = 2 \), \( k_\pi = 1.5 \) and \( k_x = 0.5 \).\(^4\) This simple policy rule described the Federal Reserve’s monetary policy over the period 1987 to 1992 surprisingly well. However, as Svensson (2003) points out, the rule is far from optimal, as the central bank should use all relevant information instead of only inflation and the output gap in period \( t \). Svensson shows that under the

---

\(^3\) See Equations (2.8) and (2.9) in Svensson (2003). To simplify and unlike Equation (2.9) in Svensson (2003), we put \( \beta_z \) to zero in Equation (4).

\(^4\) According to the so called “Taylor principal” \( k_\pi \) should be greater than one to avoid dynamic instability. Only when \( k_\pi > 1 \) the nominal short-term interest rate moves sufficiently in response to inflation to increase the real short-term interest rate (see, e.g., Taylor, 2000 and Woodford, 2001).
optimal rule in the model outlined above the central bank will set the interest rate such that it implicitly achieves:

\[
\pi_{t+1} - \pi^* = -\psi / \alpha_i \{x_{t+2} - \beta_i (i_{t+1} - \pi_{t+2}, r_{t+1}^*) \}
\]  

(6)

So, according to the optimal rule, there should be a tight relation between the interest rate set by the central bank and forecasts for inflation and output gaps. In the following sections we will examine whether a Taylor rule based on forecasts for inflation and output describes monetary policy by the ECB better than a traditional Taylor rule.

3. Empirical Framework

In empirical studies, Taylor’s rule is typically modified by including a smoothing parameter, \( \lambda \), to account for monetary policy inertia. To see how this adjusted Taylor rule relates to Taylor’s original rule, we decompose the adjusted model in two equations. Equation (7a) is identical to the original Taylor rule, while Equation (7b) fits it in a partial adjustment framework.\(^5\)

\[
\hat{i}_t = r^* + \pi^* + k_x (\pi_t - \pi^*) + k_y x_t \quad (7a)
\]

\[
i_t = (1 - \lambda) \hat{i}_t + \lambda i_{t-1} + u_t. \quad (7b)
\]

where \( i_t \) is the nominal interest rate and \( u_t \) is an iid error term.

Rudebusch (2002) criticizes the partial adjustment Taylor rule and proposes an alternative equation which includes a first-order serially correlated error instead of a partial adjustment parameter.

\[
\hat{i}_t = r^* + \pi^* + k_x (\pi_t - \pi^*) + k_y x_t \quad (8a)
\]

\[
i_t = \hat{i} + \nu_t \quad (8b)
\]

\[
\nu_t = \rho \nu_{t-1} + u_t. \quad (8c)
\]

\(^5\) Gerlach and Schnabel (2000) and Gerdesmeier and Roffia (2003) argue that this partial adjustment model fits euro area data quite well. See Gerlach (2007) for a discussion of other studies estimating a Taylor rule model for the euro area.
where $\nu$ is a serially correlated error term, $\rho$ is the serial correlation parameter and the other variables are defined as above.

English et al. (2003) combine the partial adjustment model and the serial correlation model to obtain a nested model:

\begin{align}
\hat{i}_t &= r^* + \pi^* + k_x (\pi_t - \pi^*) + k_\gamma x_t \\
i_t &= (1 - \lambda)(\hat{i}_t) + \lambda i_{t-1} + \nu_t \\
\nu_t &= \rho \nu_{t-1} + u_t,
\end{align}

where all variables and parameters are defined as above. When Equations (9a), (9b), and (9c) are combined and written in first differences, it becomes possible to distinguish empirically between hypotheses of partial adjustment and serially correlated errors:

\begin{equation}
\Delta i_t = (1 - \lambda) \Delta \hat{i}_t + (1 - \lambda)(1 - \rho)(\hat{i}_{t-1} - i_{t-1}) + \lambda \rho \Delta i_{t-1} + u_t.
\end{equation}

Equation (10) shows that the change in the nominal short-term interest rate is captured by the most recent change in the Taylor-rule rate, $\Delta \hat{i}_t$, the existing gap between the Taylor-rule interest rate and the actual interest rate in the previous period, $\hat{i}_{t-1} - i_{t-1}$, and the change in the nominal interest rate one period earlier, $\Delta i_{t-1}$. The first term on the right-hand-side, $(1 - \lambda) \Delta \hat{i}_t$, facilitates distinguishing between partial adjustment and serial correlation in the dynamics of the short-term interest rate.\(^6\)

As far as we know, only Castelnuovo (2003) has employed the framework of English et al. (2003). While he cannot exclude that serially correlated policy shocks may play a role in describing the US federal funds rate path, his results support the importance of the lagged interest rate in Taylor-type models for the Federal Reserve.

\(^6\) Therefore, Equation (10) enables identifying the effects of both partial adjustment and serially correlated errors without resorting to other evidence, such as the forecastability of the term structure, as suggested by Rudebusch (2002). The test proposed by English et al. (2003) is preferable, since a lack of forecastability of the term structure might reflect violations of the expectations hypothesis assumptions instead of a misspecification of the monetary policy rule (Söderlind et al., 2003).
4. Data

We use monthly data series for the period 1997.1-2006.12.\(^7\) Even though the common monetary policy only started in 1999, we also include observations for 1997 and 1998 as in the run-up to the currency union interest rates were clearly coordinated. Our dependent variable is the euro three-month money market rate. For 1997 and 1998 we use a weighted average of the national three-month money market interest rates. Data have been obtained from Bloomberg, Consensus Economics and Thomson Financial Datastream.

Real-time expected inflation and output growth time series have been constructed from Consensus Economics forecasts. These time series are unique, not revised and, consequently, not subject to the real-time critique of Orphanides (2001).\(^8\) Every month, major banks in the EMU-countries give their forecasts for the near future, \textit{i.e.}, the current and the next year. Euro area expected inflation and gross domestic product (GDP) growth series are constructed from these forecasts for all euro area countries except Luxembourg. For month \(m\) of a given year \(t\), the expectation (of inflation or output growth) is defined as \((13-m)/12\) times the forecast for year \(t\) plus \((m-1)/12\) times the forecast for year \(t+1\). All national series are then aggregated with annually-updated real GDP weights.

Theoretically, forecasts of the output gap should be used.\(^9\) Unfortunately, Consensus Economics does not publish forecasts of the output gap. Following Jansson and Vredin (2003), we use the ECB’s estimate of the annual potential growth rate in combination with the forecasted growth rates of GDP to construct the implied forecasts of the \textit{change} of the output gap. In several publications the ECB has indicated that trend potential growth is 2-2.5\% per annum (see, for instance, ECB 2001, 2002). We set the potential growth of output to 2.25\%, the midpoint of the interval given by the ECB.\(^10\)

Similarly, using the ECB definition of stability, \textit{i.e.} HICP inflation below, but close to, 2\% over the medium-long term, we subtract 2\% from the inflation expectations to obtain the expected inflation gap.

---

\(^7\) Appendix 1 gives the sources and definitions of the time series used in the empirical analysis.

\(^8\) Orphanides (2001) has shown that the use of real-time instead of ex-post data leads to very different estimated coefficients in Taylor rule models for the Federal Reserve.

\(^9\) Still, according to Gerlach (2007), the output gap does not seem to play any role in the ECB’s Governing Council’s motivation for policy decisions.

\(^10\) Of course, subtracting a fixed number from an explanatory variable only changes the point estimate of the constant.
As mentioned, we also estimate conventional Taylor rules for comparison purposes. For this we employ ex-post data on inflation and output, which have been obtained from Thomson Financial Datastream. The harmonized index of consumer prices (HICP) is used to measure annual inflation. The inflation gap is then defined as the difference between realized inflation and 2%. For output, we take the European industrial production index, to which we apply the Hodrick-Prescott filter (with the smoothing parameter set at $\lambda=14,400$) to obtain a measure of potential output. The output gap is calculated as the percentage deviation of actual output from trend output.\textsuperscript{11}

As a first step of the analysis, let us briefly examine the data. The Consensus and ex-post series are shown in the left and right panel of Figure 1, respectively. At first glance, the expectation and outcome series are similar, yet a closer look reveals some important differences. Expected inflation follows the short-term interest rate closely: the unconditional correlation between these variables is positive and significant. This does not hold true for realized inflation and the short-term interest rate.

\textbf{Figure 1: Consensus versus ex-post data (percentage points)}

\textit{Sample period: 1997.1-2006.12}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Figure1.png}
\caption{Consensus versus ex-post data (percentage points)}
\end{figure}

\textsuperscript{11} To enhance the reliability of our measure of the output gap, we use data from 1996 onwards.
Although both the Consensus and the ex-post output gap series reflect the movements of the euro area business cycle, the timing is different. In general, the expectations series is leading and more strongly correlated to the short-term interest rate. Interestingly, the ECB has been able to anchor both inflation expectations and inflation outcomes since 2001. In recent years actual inflation rates were often slightly above target, but inflation expectations remained close to (and mostly below) 2 percent.

Eyeballing the data, all variables seem to be stationary. Nonetheless, augmented Dickey-Fuller (1979, 1981) tests indicate the presence of a unit root in our sample for ex-post inflation and the short-term interest rate (see Appendix 2). However, as the ADF tests have low power in short samples, we also use the KPSS test which assumes stationarity under the null. According to the KPSS tests, all variables except ex-post inflation, can be treated as stationary variables. In view of the fact that since the start of the currency union, the ECB has been able to stabilize inflation at a level around 2%, we also treat inflation as a stationary variable. It seems safe to treat our variables as stationary as there has been a stable regime in place with a fixed inflation objective over this sample period.

5. Empirical results
Table 1 shows our estimation results (using least squares) for the full sample period. As the partial adjustment specification (Equations 7a and 7b) and the nested specification (Equations 9a, 9b and 9c) are estimated in non-linear form using non-linear least squares (NLS), our estimates possibly depend on the starting values for the non-linear procedure. Via a grid search we have made sure that our estimates constitute a global and not a local optimum.

Our results suggest that the nested model of English et al. (2003), shown in the last column of Table 1, is preferable to the other models, independent of whether we use ex-post or Consensus data. Two econometric findings support this claim. First, the nested model produces lower values of the Akaike and Schwarz information criteria. Second, only the nested model adequately captures the persistence in the short-term interest rate. The low Durbin-Watson and high Durbin h’s statistics indicate that the other three specifications have severe problems with respect to serial correlation.12

12 We report Newey-West (1987) standard errors to deal with this econometric difficulty.
Table 1: Estimated Taylor rules, ex-post versus Consensus data  

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard Eq. (5)</th>
<th>PA Eq.’s (7a) and (7b)</th>
<th>SC Eq.’s (8a), (8b) and (8c)</th>
<th>PA and SC Eq.’s (9a), (9b) and (9c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ex-post Consensus</td>
<td>ex-post Consensus</td>
<td>ex-post Consensus</td>
<td>ex-post Consensus</td>
</tr>
<tr>
<td>$k_o$</td>
<td>3.25*** (0.16)</td>
<td>3.11*** (0.44)</td>
<td>2.89** (1.15)</td>
<td>3.15*** (0.40)</td>
</tr>
<tr>
<td></td>
<td>3.63*** (0.11)</td>
<td>3.66*** (0.17)</td>
<td>3.16*** (0.65)</td>
<td>3.60*** (0.15)</td>
</tr>
<tr>
<td>$k_x$</td>
<td>-0.42* (0.23)</td>
<td>0.04 (0.86)</td>
<td>0.07 (0.04)</td>
<td>0.09 (0.53)</td>
</tr>
<tr>
<td></td>
<td>1.35*** (0.30)</td>
<td>1.67*** (0.59)</td>
<td>0.38* (0.22)</td>
<td>1.39*** (0.53)</td>
</tr>
<tr>
<td>$k_s$</td>
<td>0.36*** (0.07)</td>
<td>0.86** (0.43)</td>
<td>0.02** (0.01)</td>
<td>0.37 (0.24)</td>
</tr>
<tr>
<td></td>
<td>1.23*** (0.16)</td>
<td>1.65*** (0.21)</td>
<td>0.56*** (0.12)</td>
<td>1.52*** (0.22)</td>
</tr>
<tr>
<td>$\rho$</td>
<td></td>
<td>0.98*** (0.02)</td>
<td>0.98*** (0.01)</td>
<td>0.54*** (0.11)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.89*** (0.03)</td>
<td>0.43*** (0.11)</td>
<td>0.86*** (0.11)</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.96*** (0.02)</td>
<td>0.89*** (0.03)</td>
<td>0.95*** (0.02)</td>
<td>0.86*** (0.04)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.27</td>
<td>0.68</td>
<td>0.98</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>0.98</td>
<td>0.98</td>
<td>0.98</td>
<td>0.99</td>
</tr>
<tr>
<td>$AIC$</td>
<td>2.39</td>
<td>1.57</td>
<td>-1.24</td>
<td>-1.51</td>
</tr>
<tr>
<td></td>
<td>-1.47</td>
<td>-1.47</td>
<td>-1.9</td>
<td>-1.59</td>
</tr>
<tr>
<td>$BIC$</td>
<td>2.46</td>
<td>1.64</td>
<td>-1.15</td>
<td>-1.39</td>
</tr>
<tr>
<td></td>
<td>-1.37</td>
<td>-1.37</td>
<td>-1.34</td>
<td>-1.48</td>
</tr>
<tr>
<td>$DW / Durbin’s h$</td>
<td>0.33</td>
<td>0.09</td>
<td>5.46</td>
<td>-0.11</td>
</tr>
<tr>
<td></td>
<td>4.87</td>
<td>1.28</td>
<td>4.87</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Notes: Newey-West standard errors are in parentheses; */**/*** denote significance at 10%, 5% or 1% level, respectively. All equations are defined as in the text. AIC and BIC denote the Akaike and Schwarz criteria. The row identified as DW/Durbin’s h presents the Durbin-Watson test statistic for the standard and the serial correlation model (first and third column) and Durbin’s h for the partial adjustment and the nested model (second and fourth column).

The partial adjustment parameter estimate and the serial correlation parameter are significantly different from zero, suggesting both policy inertia and serially correlated errors in ECB Taylor rules. This conclusion is in line with the finding of Castelnuovo (2007) for the sample 1980-2003.

What about the difference between the preferred model based on ex post data vs. the preferred model estimated using Consensus forecasts? Table 1 shows that our results using ex-post and Consensus data differ to a large extent. To begin with, irrespective of the Taylor rule specification, the regressions based on ex-post data indicate that the ECB has followed a destabilizing policy, where the reaction...
to a rise in inflation is insufficient to keep real short-term interest rates from declining. Such accommodating behaviour constitutes a destabilizing policy with respect to inflation. In contrast, the results using survey data imply a stabilizing role of the ECB.\textsuperscript{13}

Another difference is the size and significance of the coefficient for output. Using forward-looking data, we observe that the ECB not only cares about inflation but also takes the output gap into account, in contrast to the model based on ex post data. Also Gerlach (2007) concludes that expectations of economic growth play an important role in the ECB’s interest rate decisions. So either the expected output growth contains information on future price developments or the ECB is not an ‘inflation nutter’, as sometimes suggested by its critics.

Table 2 presents the outcomes of various robustness checks. The first column replicates our preferred model of Table 1. In the next three columns we add three variables that may also contain information on future inflation and output (Castelnuovo, 2007). In column (2) we add money growth. In the ECB monetary policy strategy money plays a role, although there is some debate on how important it really is (see Berger \textit{et al.}, 2006). In column (3) we add the risk premium, defined as the difference between the yield on a ten-year euro area government benchmark bond and the yield on (a basket of) long-term euro area corporate loans, rated BBB.\textsuperscript{14} In column (4) we add the euro-dollar exchange rate.

In the final column we show the results using an alternative way to calculate expected inflation and output growth. Under this alternative, expected inflation in year $t$ is constructed by aggregating national inflation forecasts for year $t+1$, while expected output growth in year $t$ is constructed by aggregating national growth forecasts for year $t$. This methodology results in a time-varying forecast horizon, because forecasts are made monthly for annual inflation and growth rates. The shorter forecast horizon for output reflects the standard view on the transmission mechanism of monetary policy.

\textsuperscript{13} Sauer and Sturm (2007) also find this, based on different expectations and ex-post data, and for a different sample period (up to 2003).

\textsuperscript{14} Using a Taylor rule framework, Gerlach-Kristen (2004) finds that the Federal Reserve seems to react to financial markets conditions, empirically approximated by the risk spread between the yield on a safe ten-year Treasury note and the yield on risky corporate bond index. In an earlier paper on the ECB, Gerlach-Kristen (2003) includes the long-term interest rate as an additional explanatory variable in her Taylor rule model.
As Table 2 shows, our results are robust for adding other variables that might contain information about future inflation. In all models none of these variables turn out to be significant. On the other hand, our results are sensitive to the way we construct our expectation variables as the coefficient of the inflation gap becomes insignificant in the final column of Table 2. Possibly, the changing forecast horizon of our alternative weighing scheme produces inaccurately measured expectations. Under weighing scheme B, inflation expectations are, conditional on the model, unrelated to the policy rate, which is rather implausible.
Moreover, noise seems to have pushed down the estimate of the output coefficient, as one would expect with an ‘errors-in-variable’ problem.

Finally, as an additional robustness test, we treat the Consensus forecasts as endogenous variables and estimate the benchmark model by the generalized method of moments (GMM). As instruments we use the second and third lag of expected inflation, the expected change of the output gap and ex-post inflation. To test the joint validity of our instrument set, we employ the Sargan test. The result of this test indicates that the instrument set is valid (p-value = 0.91). As shown in Table 3, the NLS and GMM results are very similar. Consequently, endogeneity of the Consensus forecasts does not seem to drive our main results.

Table 3. NLS vs GMM: The benchmark model

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Benchmark model using NLS</th>
<th>Benchmark model using GMM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Consensus</td>
<td>Consensus</td>
</tr>
<tr>
<td>$k_o$</td>
<td>3.60*** (0.15)</td>
<td>3.65*** (0.11)</td>
</tr>
<tr>
<td>$k_\pi$</td>
<td>1.39*** (0.53)</td>
<td>1.59*** (0.43)</td>
</tr>
<tr>
<td>$k_y$</td>
<td>1.52*** (0.22)</td>
<td>1.51*** (0.23)</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.43*** (0.11)</td>
<td>-0.54 2.11</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>0.86*** (0.04)</td>
<td>0.85*** (0.04)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.99 0.97</td>
<td>2.13 (0.91)</td>
</tr>
</tbody>
</table>

Notes: Newey-West standard errors are in parentheses; */**/*** denote significance at 10%, 5% or 1% level, respectively. The instrument set used in the GMM estimation includes the second and third lag of expected inflation, expected change of the output gap and ex-post inflation as instruments. Given the persistence in the time series, these instruments are highly relevant. Sargan test corresponds to the Sargan overidentifying restrictions test (p-value is in parentheses).
6. Conclusion

During the last decade, Taylor rules have been proposed as effective frameworks within which monetary policy can be accurately described. However, as pointed out by Svensson (2003), even if the ultimate objective of monetary policy is to stabilize inflation and output, a simple Taylor rule will not be optimal in a reasonable macroeconomic model. Realized outcomes for inflation and output enter the optimal decision rule if they help to predict future inflation and output, but so will any other variable that provides information concerning future inflation and output. So monetary policy will, in general, be more complicated than the simple Taylor rule suggests.

In this paper we analyse whether monetary policy of the ECB over the 1997.1-2006.12 period can be better understood by examining how policy decisions are related to forecasts for inflation and output. We therefore estimate Taylor rules for the euro area using expectations for inflation and output growth in our Taylor rule model for the ECB and compare these estimates with a more conventional specification in which outcomes for inflation and output are used. According to the model estimated with forward-looking data, the ECB takes expected inflation and expected output growth into account in setting interest rates, while in the more conventional model specification the coefficient of inflation is not significantly different from zero. Consequently, we find that the ECB’s accommodating behaviour implied by contemporaneous Taylor rules seems to be mainly driven by the lack of a forward-looking perspective. Furthermore, as both theory and practice suggest that monetary policy needs to be forward-looking in order to be stabilizing, we consider the forward-looking ECB Taylor rules based on Consensus data more appropriate than the contemporaneous ones based on ex-post data.

Our analysis is based on a framework suggested by English et al. (2003) that allows distinguishing between policy inertia and serially correlated errors. Our estimates lend support to both policy inertia and serially correlated errors in ECB Taylor rules.
Appendix 1. Sources and definitions of time series

Interest rate

- Euro area three-month nominal interest rate is used as dependent variable in the analysis. This series has been obtained from Thomson Financial Datastream. Before 1999 it corresponds to the real GDP-weighted average of national three-month nominal interest rates, as from 1999 it corresponds to EURIBOR.

Consensus data

- Expected inflation is constructed from averages of consumer inflation forecasts published by Consensus Economics for all euro area countries except Luxembourg. For month \( m \) of a given year \( t \), the expectation is defined as \((13-m)/12\) times the forecast for year \( t \) plus \((m-1)/12\) times the forecast for year \( t+1 \). An alternative to our main weighing scheme is weighing scheme B. Under this alternative, expected inflation in year \( t \) is constructed by aggregating national inflation forecasts for year \( t+1 \). Under both weighing schemes, the national series are aggregated with annually-updated real GDP weights. The expected inflation gap is then defined as expected inflation minus 2%.

- Expected real GDP growth is constructed from averages of real GDP growth forecasts published by Consensus Economics for all euro area countries except Luxembourg. For month \( m \) of a given year \( t \), the expectation is defined as \((13-m)/12\) times the forecast for year \( t \) plus \((m-1)/12\) times the forecast for year \( t+1 \). An alternative to this central weighing scheme is also used, weighing scheme B. Under this alternative, expected inflation in year \( t \) is constructed by aggregating national inflation forecasts for year \( t \). For the aggregation of national series, annually-updated real GDP weights are used. The expected change in the output gap is finally defined as expected real GDP growth minus 2.25%.

Ex-post data

- Annual inflation for the euro area is derived from the harmonized index of consumer prices (HICP). This series is not adjusted for seasonality and obtained from Thomson Financial.

- For our measure of the euro area output gap, we use seasonally-adjusted and working day adjusted industrial production, obtained from Thomson Financial. We apply a standard Hodrick-Prescott filter with the smoothing parameter of \( \lambda = 14,400 \) and calculate the output gap as the percentage deviation of actual production from trend.

- Money growth is measured by the annual change in the M3 aggregate for the euro area. This series is from Thomson Financial.
• Risk spread is defined as the difference between the yield on a 10 year euro area government benchmark bond and the yield on (a basket of) euro area corporate loans, rated BBB. We have obtained these series from Bloomberg.

• The euro-dollar exchange rate has been constructed. Before 1999/the introduction of the euro, we have used the ecu-dollar exchange rate. As from 1999, the actual euro-dollar exchange rate has of course been used. Both series have been obtained from Thomson Financial.
## Appendix 2. Time series properties of key variables

<table>
<thead>
<tr>
<th></th>
<th>ADF tests</th>
<th>KPSS tests (c,t)</th>
<th>KPSS tests (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># Lags</td>
<td>Test statistic</td>
<td>Critical values</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>ex-post interest rate</td>
<td>-</td>
<td>-0.71</td>
<td>-2.59</td>
</tr>
<tr>
<td>inflation gap</td>
<td>c</td>
<td>-2.35</td>
<td>-3.49</td>
</tr>
<tr>
<td>output gap</td>
<td>-</td>
<td>-2.59</td>
<td>-2.58</td>
</tr>
<tr>
<td>Consensus inflation gap</td>
<td>-</td>
<td>-2.11</td>
<td>-2.59</td>
</tr>
<tr>
<td>output gap</td>
<td>-</td>
<td>-2.11</td>
<td>-2.59</td>
</tr>
</tbody>
</table>

Note: 'c' and 't' stand for, respectively, constant and trend included in the testing equation. * based on 5% critical values.
References


| No. 124 | Andrew Hughes, Rasmus Kattai and John Lewis | Early Warning or Just Wise After the Event? The Problem of Using Cyclically Adjusted Budget Deficits for Fiscal Surveillance |
| No. 125 | Kerstin Bernoth, Juergen von Hagen and Casper de Vries | The Forward Premium Puzzle: new Evidence from Futures Contracts |
| No. 126 | Alexandra Lai, Nikil Chande and Sean O’Connor | Credit in a Tiered Payments System |
| No. 127 | Jean-Charles Rochet and Jean Tirole | Must-Take Cards and the Tourist Test |
| No. 128 | James McAndrews and Zhu Wang | Microfoundations of Two-sided Markets: The Payment Card Example |
| No. 129 | John P. Jackson and Mark J. Manning | Central Bank intraday collateral policy and implications for tiering in RTGS payment system |
| No. 130 | John Lewis | Hitting and Hoping? Meeting the Exchange Rate and Inflation Criteria During a Period of Nominal Convergence |
| No. 131 | Paul T. de Beer and Robert H.J. Mosch | The waning and restoration of social norms: a formal model of the dynamics of norm compliance and norm violation |
| No. 132 | Carin van der Crujsen and Sylvester Eijffinger | The economic impact of central bank transparency: a survey |
| No. 133 | Elisabeth Ledrut | Simulating retaliation in payment systems: Can banks control their exposure to a failing participant? |
| No. 134 | Peter Wierts | The sustainability of euro area debt: a re-assessment |
| No. 135 | W J. Willemse and R. Kaas | Rational reconstruction of frailty-based mortality models by a generalisation of Gompertz’ law of mortality |
| No. 136 | Nicole Jonker and Thijs Kettenis | Explaining cash usage in the Netherlands: the effect of electronic payment instruments |
| No. 137 | Paul Cavelaars and Jeroen Hesssel | Regional Labour Mobility in the European Union: Adjustment Mechanism or Disturbance? |
| No. 138 | Yakov Ben-Haim | Info-Gap Robust-Satisficing and the Probability of Survival |
| No. 139 | Andreas Pick | Financial contagion and tests using instrumental variables |
| No. 140 | Cheng Hsiao, Hashem Pesaran and Andreas Pick | Diagnostic Tests of Cross Section Independence for Nonlinear Panel Data Models |
| No. 141 | Donato Masclandaro, Maria Nieto and Henriëtte Prast | Who pays for banking supervision? Principles and practices |
| No. 142 | Marco Lombardi and Silvia Sgherri | (Un)naturally Low? Sequential Monte Carlo Tracking of the US Natural Interest Rate |
| No. 143 | Michiel van Leuvensteijn, Jacob Bikker, Adrian van Rixtel and Christoffer Kok-Sørensen | A new approach to measuring competition in the loan markets of the euro area |
| No. 144 | Allard Bruinshoofd and Leo de Haan | Market timing and corporate capital structure: A transatlantic comparison |
| No. 145 | Leo de Haan and Jan Kakes | Are non-risk based capital requirements for insurance companies binding? |
| No. 146 | Maarten van Rooij, Annamaria Lusardi and Rob Alessie | Financial literacy and stock market participation |
| No. 147 | Jan Marc Berk and Job Swank | Regional Real Exchange Rates and Phillips Curves in Monetary Unions: Evidence from the US and EMU |
| No. 148 | David-Jan Jansen and Jakob de Haan | The Importance of Being Vigilant: Has ECB Communication Influenced Euro Area Inflation Expectations? |
| No. 149 | Maria Demertzis and Nicola Viegi | Inflation Targeting: a Framework for Communication |
| No. 150 | Jan Jacobs, Pieter Otter and Ard den Reijer | Information, data dimension and factor structure |
| No. 151 | John Lewis and Karsten Staehr | The Maastricht Inflation Criterion: What is the Effect of Expansion of the European Union? |
| No. 152 | Tamim Bayoumi and Silvia Sgherri | On the Impact of Income and Policy Shocks on Consumption |
| No. 153 | Jacob Bikker, Dirk Broeders and Jan de Dreu | Identifying regional and sectoral dynamics of the Dutch staffing labour cycle |
| No. 154 | Jacob Bikker, Laura Spierdijk and Paul Finnie | Stock market performance and pension fund investment policy: rebalancing, free float, or market timing? |
| No. 155 | Christine Beijnen and Wilko Bolt | Size matters: economies of scale in European payments processing |
| No. 156 | Jacob Bikker, Laura Spierdijk and Paul Finnie | The impact of market structure, contestability and institutional environment on banking competition |
| No. 157 | Alessandro Riboni and Francisco Ruge-Murcia | Preference heterogeneity in monetary policy committees |
| No. 158 | E. Philip Davis, Sybille Grob and Leo de Haan | Pension fund finance and sponsoring companies: empirical evidence on theoretical hypotheses |
Maarten van Rooij, Arjen Siegmann and Peter Vlaar, Market valuation, pension fund policy and contribution volatility