

Taylor Rules for the ECB using Expectations Data*

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Abstract

We estimate Taylor rules for the euro area using Consensus Economics data for expected inflation and output growth, and compare these estimates with more conventional specifications in which actual outcomes are used. We find that 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 realized inflation is not significantly different from zero.

Keywords: Taylor rule; ECB; real-time data; policy inertia; serial correlation

JEL classification: C22; E52

I. 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 sizeable lag. Therefore, monetary policy has to be forward-looking, i.e., it should be based on

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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 for the period 1997.1–2006.12. 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.

The remainder of the paper is structured as follows. The next section gives a motivation for our Taylor rule with forward-looking data, following Svensson (2003). In Section III we outline our framework and in Section IV we discuss the variables used in our estimations. Section V contains estimates of several Taylor-rule models. Section VI offers some concluding comments.

II. Theoretical Background

Taylor (1993) proposed the following rule:

$$\hat{i}_t = r^* + \pi^* + k_\pi(\pi_t - \pi^*) + k_x x_t, \quad (1)$$

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 t from the inflation target π^* , 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 $k_x = 0.5$.² This simple policy rule described the Federal Reserve's monetary policy over the period 1987–1992 surprisingly well. However, as Svensson (2003) points out, the rule is far from optimal, as the central bank should

¹ Previous recent studies include Gerlach and Schnabel (2000), Surico (2003), Carstensen and Colavecchio (2004), Fourçans and Vranceanu (2004), Gerdesmeier and Roffia (2004), Gerlach (2007), and Sauer and Sturm (2007). See de Haan, Eijffinger and Waller (2005) for a discussion of the ECB's policies and Gerlach (2004) for a critique of these policies.

² According to the so-called “Taylor principle”, k_π 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 (1999) and Woodford (2001).

use all relevant information instead of only inflation and the output gap in period t .

Following Svensson (2003), this section provides some intuition as to why expectations concerning inflation and output should play a role in describing monetary policy.³ Consider an intertemporal loss function consisting of the expected sum of discounted current and future losses,

$$E \left[(1 - \delta) \sum_{\tau=0}^{\infty} \delta^{\tau} L_{t+\tau} | I_t, z^t \right], \quad (2)$$

where $E[\cdot | I_t, z^t]$ 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^t , while δ ($0 < \delta < 1$) is the discount factor. The loss in period t , L_t , is a weighted sum of the squared inflation gap ($\pi_t - \pi^*$ where π^* is the inflation objective) and the squared output gap (x_t),

$$L_t = \frac{1}{2} [(\pi_t - \pi^*)^2 + \psi x_t^2], \quad (3)$$

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, equation (2), 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.⁴ The aggregate-supply and aggregate-demand equations are

$$\pi_{t+1} - \pi = \delta(\pi_{t+2|t} - \pi) + \alpha_x x_{t+1|t} + \alpha_z z_{t+1} + \varepsilon_{t+1}, \quad (4)$$

$$x_{t+1} = x_{t+2|t} - \beta_r(i_{t+1|t} - \pi_{t+2|t} - r_{t+1}^*) + \eta_{t+1}, \quad (5)$$

where $\pi \equiv E[\pi_t]$ is the average inflation rate, z_{t+1} is a vector of exogenous variables in period $t+1$ that are not known in period t and earlier periods, ε_{t+1} and η_{t+1} are i.i.d. "cost-push" and "excess-demand" shocks, and r_t^* 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 policy rule will not be a simple Taylor rule—it will include the central bank's expectations about z .

³ We thank the editor for this suggestion. The model does not take interest-rate smoothing into account, but our empirical work does.

⁴ See equations (2.8) and (2.9) in Svensson (2003). To simplify, and unlike equation (2.9) in Svensson (2003), we put β_z to zero, as a result of which the central bank's expectations about z do not enter equation (5).

For the model outlined above, Svensson (2003) shows that the optimal interest-rate decision is given by:⁵

$$i_{t+1} = r_{t+1,t}^* + \pi^* + (\pi_{t+2,t} - \pi^*) + \frac{\alpha_x}{\psi \beta_r} (\pi_{t+1,t} - \pi^*) + \frac{1}{\beta_r} (x_{t+2,t}). \quad (6)$$

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 the output gap. Intuitively, these forecasts reflect perceived future shocks to the economy, which the central bank tries to stabilize. 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.

III. Empirical Framework

Various Taylor rule studies include the lagged interest rate as an explanatory variable in the model, as in e.g. Clarida, Galí and Gertler (1998), assuming that central banks dislike jumps in the short-term interest rate and prefer interest-rate smoothing. Taylor's rule can be easily modified by including a smoothing parameter, λ , 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:⁶

$$\hat{i}_t = r^* + \pi^* + k_\pi (\pi_t - \pi^*) + k_x x_t, \quad (7a)$$

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

where i_t is the nominal interest rate and u_t is an i.i.d. error term.

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

$$\hat{i}_t = r^* + \pi^* + k_\pi (\pi_t - \pi^*) + k_x x_t, \quad (8a)$$

$$i_t = \hat{i}_t + v_t. \quad (8b)$$

⁵ To arrive at equation (6), combine equations (5.6) and (5.7) in Svensson (2003) for $\tau = 0$, assuming $\beta_z = 0$ and $i_{t+1,t} = i_{t+1}$. Note that in this model, the central bank instrument in period t is actually the announcement of the future interest rate, $i_{t+1,t}$, rather than the current interest rate, i_t .

⁶ Gerdesmeier and Roffia (2004) 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.

$$v_t = \rho v_{t-1} + u_t, \quad (8c)$$

where v is a serially correlated error term, ρ is the serial correlation parameter and the other variables are defined as above.

English, Nelson and Sack (2003) combine the partial adjustment model and the serial correlation model to obtain a nested model:⁷

$$\hat{i}_t = r^* + \pi^* + k_\pi(\pi_t - \pi^*) + k_x x_t, \quad (9a)$$

$$i_t = (1 - \lambda)\hat{i}_t + \lambda i_{t-1} + v_t, \quad (9b)$$

$$v_t = \rho v_{t-1} + u_t, \quad (9c)$$

where all variables and parameters are defined as above. When equations (9a), (9b) and (9c) are combined and written in first differences, we obtain:

$$\Delta i_t = (1 - \lambda)\Delta\hat{i}_t + (1 - \lambda)(1 - \rho)(\hat{i}_{t-1} - i_{t-1}) + \lambda\rho\Delta i_{t-1} + u_t. \quad (10)$$

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, Δi_{t-1} .

The first term on the RHS of equation (10), $(1 - \lambda)\Delta\hat{i}_t$, facilitates distinguishing between partial adjustment and serial correlation in the dynamics of the short-term interest rate.⁸ In practice, however, identifying the effects of both partial adjustment and serially correlated errors can be troublesome, especially over a relatively short sample period.⁹

⁷ Castelnuovo (2003a,b) employs the framework suggested by English *et al.* (2003) to analyse the US federal funds rate path, and Castelnuovo (2007) applies it in the euro area context. The results for the US and the euro area are similar: while it cannot be excluded that serially correlated policy shocks play a role, the results of Castelnuovo support the importance of the lagged interest rate in Taylor-type models.

⁸ Therefore the English *et al.* (2003) approach 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). As noted by Söderlind, Söderström and Vredin (2005), 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.

⁹ The approach of English *et al.* relies on some restrictive assumptions, namely that the smoothing is only of first order, the error term is AR(1), and the error term is orthogonal to the regressors. If, for instance, the error structure is more complicated than the assumed AR(1) process, the results may be biased towards partial adjustment; see Rudebusch (2006).

IV. Data

We use monthly data series for the period 1997.1–2006.12.¹⁰ 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 forecasts are used as a proxy for the ECB's expectations of inflation and output growth. The Consensus data are unique, not revised and, consequently, not subject to the real-time critique of Orphanides (2001).¹¹ Every month, major banks in the EMU countries give their forecasts for the near future, 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.¹² Unfortunately, Consensus Economics does not publish forecasts of the output gap. Lacking forecasts of the *level* of the output gap, we construct forecasts of the *change* of the output gap.¹³ For this we use the ECB's estimate of the annual potential growth rate in combination with the forecasted growth rates of GDP. 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.¹⁴

¹⁰ The Appendix gives the sources and definitions of the time series used in the empirical analysis.

¹¹ 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.

¹² 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.

¹³ Walsh (2004) argues that a Taylor rule in which the level of the output gap is replaced by its change performs quite well in the presence of imperfect information about the output gap. Given that output gaps are notoriously difficult to measure and tend to be revised substantially over time, this appears quite plausible.

¹⁴ Of course, subtracting a fixed number from an explanatory variable only changes the point estimate of the constant.

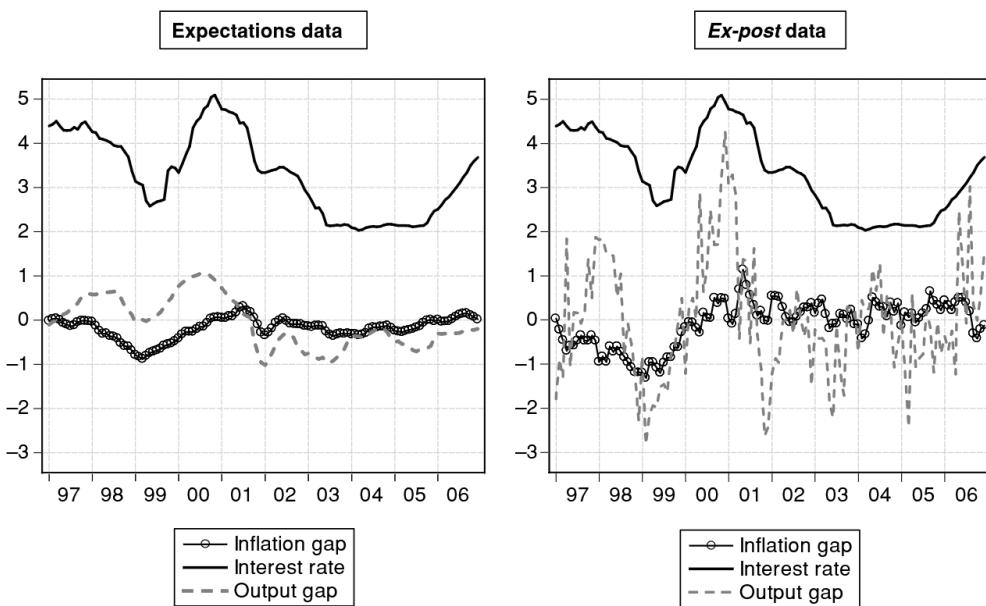


Fig. 1. Expectations versus *ex-post* data (percentage points); sample period 1997.1–2006.12

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

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.¹⁵

Let us first briefly examine the data. The expectations and *ex-post* series are shown in the left and right panels of Figure 1, respectively. At first glance, the expectations 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. Although both the expectations 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.

¹⁵ To enhance the reliability of our measure of the output gap, we use data from 1996 onwards.

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%.

Eyeballing the data, all variables seem to be stationary. Nonetheless, the augmented Dickey–Fuller (1979, 1981) test results do not allow us to reject the presence of a unit root for *ex-post* inflation and the short-term interest rate (see Table A1). As this finding could be explained by the low power of ADF tests in short samples, we also employ KPSS tests, both with and without a time trend included. According to KPSS tests with a constant, the null hypothesis of stationarity is rejected for *ex-post* inflation, the interest rate and the expected output gap series. However, from an economic point of view, the arguments for stationarity are very strong, as there has been a stable monetary regime in place with a fixed inflation objective. Consequently, it seems safe to treat our variables as stationary.

V. 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 expectations 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's *h* statistics indicate that the other three specifications have severe problems with respect to serial correlation.¹⁶

The partial adjustment parameter estimate and the serial correlation parameter are significantly different from zero. Although one should be careful to draw strong conclusions from this finding (see footnote 9), it suggests both policy inertia and serially correlated errors in the ECB Taylor rule. This result is in line with the findings 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 expectations data? Table 1 shows that our results using *ex-post* and expectations data differ to

¹⁶ We report Newey–West (1987) standard errors to deal with this econometric difficulty.

Table 1. Estimated Taylor rules, ex-post vs. expectations data; sample period: 1997.1–2006.12

Coefficient of:	Standard		PA		SC		PA and SC	
	Eq. (5)	Ex-post	Eqs. (7a) and (7b)		Ex-post	Expectations	Eqs. (9a), (9b) and (9c)	
			Ex-post	Expectations			Ex-post	Expectations
$r^* + \pi^*$	3.25*** (0.16)	3.63*** (0.11)	3.11*** (0.44)	3.66*** (0.17)	2.89** (1.15)	3.16*** (0.65)	3.15*** (0.40)	3.60*** (0.15)
k_π	-0.42* (0.23)	1.35*** (0.30)	0.04 (0.86)	1.67*** (0.59)	0.07 (0.04)	0.38* (0.22)	0.09 (0.53)	1.39*** (0.53)
k_x	0.36*** (0.07)	1.23*** (0.16)	0.86** (0.43)	1.65*** (0.21)	0.02** (0.01)	0.56*** (0.12)	0.37 (0.24)	1.52*** (0.22)
ρ					0.98*** (0.02)	0.98*** (0.01)	0.54*** (0.11)	0.43*** (0.11)
λ			0.96*** (0.02)	0.89*** (0.03)		0.95*** (0.02)		0.86*** (0.04)
\bar{R}^2	0.27	0.68	0.98	0.98	0.98	0.98	0.99	0.99
AIC	2.39	1.57	-1.24	-1.47	-1.19	-1.43	-1.51	-1.51
BIC	2.46	1.64	-1.15	-1.37	-1.10	-1.34	-1.39	-1.48
DW/Durbin's h	0.33	0.09	5.46	4.87	0.98	1.28	-0.11	0.36

Notes: Newey-West standard errors are in parentheses; *, **, and *** denote significance at 10%, 5% and 1% level, respectively. All equations are defined as in the text. AIC and BIC denote the Akaike and Schwarz criteria, respectively. 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 columns) and Durbin's h for the partial adjustment and the nested model (second and fourth columns).

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.¹⁷

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. Gerlach (2007) also 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; see 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, de Haan and Sturm (2006). In column (3) we add the risk premium, defined as the difference between the yield on a 10-year euro area government benchmark bond and the yield on (a basket of) long-term euro area corporate loans, rated BBB.¹⁸ 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.

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 turns out to be significant. On the other hand, our results are

¹⁷ Sauer and Sturm (2007) also find this, based on different expectations and *ex-post* data, and for a different sample period (up to 2003).

¹⁸ Using a Taylor-rule framework, Gerlach-Kristen (2004) finds that the Federal Reserve seems to react to financial market conditions, empirically approximated by the risk spread between the yield on a safe 10-year Treasury note and the yield on a 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.

Table 2. Robustness checks: sample period: 1997.1–2006.12

Coefficient of:	(1)		(2)		(3)		(4)		(5)	
	Benchmark		Additional variable: M3 growth		Additional variable: risk spread		Additional variable: euro–dollar exchange rate		Expectations	
	<i>Ex-post</i>	Expectations	<i>Ex-post</i>	Expectations	<i>Ex-post</i>	Expectations	<i>Ex-post</i>	Expectations	<i>Ex-post</i>	Expectations
$r^* + \pi^*$	3.15*** (0.40)	3.60*** (0.15)	4.21** (1.61)	3.28*** (0.70)	3.50*** (0.48)	3.47*** (0.23)	6.44** (2.54)	5.28*** (1.07)	5.28*** (0.23)	3.76*** (0.23)
k_π	0.09 (0.53)	1.39*** (0.53)	0.24 (0.72)	1.26** (0.58)	0.27 (0.68)	1.31** (0.53)	-0.08 (0.37)	1.21** (0.49)	1.21** (1.20)	1.72 (1.20)
k_x	0.37 (0.24)	1.52*** (0.22)	0.34 (0.22)	1.59*** (0.28)	0.38 (0.25)	1.53*** (0.21)	0.25 (0.16)	1.31*** (0.21)	1.31*** (0.21)	0.98*** (0.28)
ρ	0.54*** (0.11)	0.43*** (0.11)	0.53*** (0.09)	0.43*** (0.09)	0.54*** (0.10)	0.43*** (0.11)	0.57*** (0.16)	0.45*** (0.13)	0.45*** (0.13)	0.47*** (0.08)
λ	0.95*** (0.02)	0.86*** (0.04)	0.94*** (0.03)	0.86*** (0.03)	0.95*** (0.02)	0.86*** (0.04)	0.92*** (0.04)	0.83*** (0.04)	0.83*** (0.04)	0.91*** (0.03)
γ			-0.16 (0.24)	0.05 (0.10)	0.42 (0.70)	-0.14 (0.21)	-2.98 (2.27)	-1.57 (1.01)	-1.57 (1.01)	
\bar{R}^2	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
AIC	-1.51	-1.59	-1.50	-1.63	-1.49	-1.58	-1.50	-1.65	-1.65	-1.55
BIC	-1.39	-1.48	-1.36	-1.49	-1.35	-1.44	-1.36	-1.51	-1.51	-1.43
Durbin's h	-0.11	0.36	0.10	0.15	-0.11	0.35	-0.37	0.30	0.30	0.17

Notes: Newey–West standard errors are in parentheses; *, ** and *** denote significance at 10%, 5% and 1% level, respectively. All equations are as defined in the text. AIC and BIC denote the Akaike and Schwarz criteria, respectively.

Table 3. NLS vs. GMM: the benchmark model; sample period: 1997.1–2006.12

Coefficient of:	Benchmark model using NLS Expectations	Benchmark model using GMM Expectations
$r^* + \pi^*$	3.60*** (0.15)	3.65*** (0.11)
k_π	1.39*** (0.53)	1.59*** (0.43)
k_x	1.52*** (0.22)	1.51*** (0.23)
ρ	0.43*** (0.11)	-0.54 (2.11)
λ	0.86*** (0.04)	0.85*** (0.04)
\bar{R}^2	0.99	0.97
Sargan test (p -value)		2.13 (0.91)

Notes: Newey-West standard errors are in parentheses; *, ** and *** denote significance at 10%, 5% and 1% level, respectively. The instrument set used in the GMM estimation includes the second and third lags 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. The Sargan test corresponds to the Sargan overidentifying restrictions test (p -value is in parenthesis).

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 weighting scheme produces inaccurately measured expectations. Under weighting 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 lags 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.

VI. 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 indications of accommodating behaviour by the ECB implied by contemporaneous Taylor rules seem 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 expectations data more appropriate than the contemporaneous ones based on *ex-post* data.

Appendix. Sources, Definitions and Properties of Time Series

Interest Rate

Euro area three-month nominal interest rate is used as the 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 of 1999 it corresponds to EURIBOR.

Expectations Data

- (i) 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 weighting scheme is weighting scheme B. Under this alternative, expected inflation in year t is constructed by aggregating national inflation forecasts for year $t + 1$. Under both weighting schemes, the national series are aggregated with annually updated real GDP weights. The expected inflation gap is then defined as expected inflation minus 2%.

Table A1. Time-series properties of key variables

		ADF tests						KPSS tests (c, t)						KPSS tests (c)					
		No. of lags	Test statistic	Critical values		Integration order ^a	Test statistic	Critical values		Integration order ^a	Test statistic	Critical values		Integration order ^a	Test statistic	Critical values			
				1%	5%			1%	5%			1%	5%			1%	5%	10%	
Ex-post	Interest rate	—	—	-0.71	-2.59	-1.94	-1.62	I(1)	0.10	0.22	0.15	0.12	I(0)	0.70	0.74	0.46	0.35	I(1)	
	Inflation gap	c	0	-2.35	-3.49	-2.89	-2.58	I(1)	0.16	0.22	0.15	0.12	I(1)	0.68	0.74	0.46	0.35	I(1)	
	Output gap	—	2	-2.59	-2.58	-1.94	-1.62	I(0)	0.05	0.22	0.15	0.12	I(0)	0.05	0.74	0.46	0.35	I(0)	
Expectations	Inflation gap	—	1	-2.11	-2.59	-1.94	-1.62	I(0)	0.08	0.22	0.15	0.12	I(0)	0.23	0.74	0.46	0.35	I(0)	
	Output gap	—	1	-2.11	-2.59	-1.94	-1.62	I(0)	0.11	0.22	0.15	0.12	I(0)	0.69	0.74	0.46	0.35	I(1)	

Notes: 'c' and 't' stand for, respectively, constant and trend included in the testing equation.

^aBased on 5% critical values.

- (ii) 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 weighting scheme is also used, weighting scheme B. Under this alternative, expected output growth in year t is constructed by aggregating national output growth 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 defined as expected real GDP growth minus 2.25%.

Ex-post Data

- (i) Annual inflation for the euro area is derived from the harmonized index of consumer prices (HICP). This series is not adjusted for seasonality and was obtained from Thomson Financial.
- (ii) 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.
- (iii) Money growth is measured by the annual change in the M3 aggregate for the euro area. This series is from Thomson Financial.
- (iv) 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.
- (v) The euro–dollar exchange rate has been constructed. Before 1999, we have used the ECU–dollar exchange rate. As from 1999, the actual euro–dollar exchange rate has of course been used. Both series were obtained from Thomson Financial.

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