‘Ex-ante’ Taylor rules
– Newly discovered evidence from the G7 countries

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Abstract

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Keywords: Taylor rule, expectation formation, monetary policy
JEL classification: E52, D84, C33

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1 Introduction

In his seminal paper John B. Taylor (1993) explains the development of the short-term interest rate in terms of a monetary policy reaction function of the Federal Reserve Bank (Fed). The Fed sets the short-term interest rate in accordance with an equilibrium rate from which it deviates whenever actual inflation and/or actual output deviate from target levels. The so-called Taylor rule has been extended in several ways especially by taking into account the forward-looking behavior of central banks and their intention to smooth the interest rate adjustment. Such Taylor-type rules have gained significant importance in both monetary theory and policy. Although the structure of Taylor-type rules is simple, it captures the essence of the behavior of the monetary authority. Probably due to this feature, the application of Taylor-type rules for describing central bank behavior is not only limited to the academic community. Applications can also be found in various publications of the financial industry when commercial banks and others intend to describe and forecast central bank behavior.

As the pioneers of the application of Taylor rules, Clarida et al. (1998) use ex-post revised data and find that the monetary policy of the G7 central banks is Taylor-rule based. In order to precisely describe the information set of the central bank, Orphanides (2001a) estimates the Taylor rule on the basis of real-time data instead of revised data. The present paper moves one step further and uses forecasts, i.e., ex-ante data to estimate Taylor-type rules. We use the Consensus Economic Forecast poll which includes interest rate, real output growth and inflation rate forecasts for the G7 countries. This unique data set allows us to analyze the fundamental question that relates the financial market to the Taylor rule, i.e., whether the financial market applies Taylor-type rules to forecasts of macroeconomic variables.

Since the Taylor-type rules state that output, inflation and the interest rate are linked through a certain relationship, it is possible to check whether the financial markets' forecasts are internally consistent (i.e., display relationships known from estimation of Taylor-type rules) or whether they are inconsistent in a sense that financial market participants talk a lot about Taylor rules when describing the observed behavior of a central bank but neglect this reasoning in their forecasts of the short-term interest rate, the inflation rate, and output changes. In this paper we, thus, change the perspective of looking at interest rate rules from the typical use in the academic literature as a reaction function explaining central bank behavior to the important issue of 'rules versus discretion'. We analyze whether, in the perception of the financial market, the G7 central banks are assumed to be rule-based. We refer to this as 'ex-ante' Taylor rules.

The paper is structured as follows: The subsequent section 2 sets out the concept of Taylor-type rules and briefly presents the core results that have emerged from the respective empirical literature as a yardstick for the subsequent analysis. Section 3 describes the data employed while section 4 presents the results. Section 5 investigates whether the long-term inflation target of the respective central bank is reflected in financial market forecasts while section 6 concludes.

2 The morphology of Taylor-type rules

Since the seminal paper of Taylor (1993), it has virtually become conventional to describe the interest rate setting behavior of central banks in terms of monetary policy reaction functions. In its plain form, the so-called Taylor rule states that the short-term interest rate which, in this analysis, represents the instrument of a central bank reacts to deviations of inflation and output from their respective targets. Clarida et al. (1998) proposed a forward-looking variant of the Taylor rule which takes into account the pre-emptive nature of monetary policy as well as an interest smoothing behavior of central banks. This particular type of reaction function has become very popular in applied empirical research on Taylor rules, but it is still in the spirit of the original Taylor rule. Formulations of this type represent a modification of the original Taylor rule. Therefore, the literature often refers to them as Taylor-type rules.

A number of studies demonstrate that the monetary policy of industrialized countries can be explained by this kind of reaction function. The most prominent studies are Taylor (1999), Judd and Rudebusch (1998) and Clarida et al. (2000). While Taylor (1999) examines the fit of the original Taylor rule, Judd and Rudebusch (1998) incorporate interest rate smoothing in a modified version. Finally, Clarida et al. (2000) introduce forward-looking elements. All authors demonstrate that the monetary policy can reasonably well be explained by Taylor-type rules.[1]

Following Clarida et al. (1998, 2000) the baseline forward-looking policy rule takes the form:

$$i_t^* = \bar{i} + \alpha_1 E_t(\pi_{t+k} - \pi^*) + \alpha_2 E_t(y_{t+k} - y_{t+k}^*), \tag{1}$$

where i^* is the desired level of the nominal short-term interest rate, and $\bar{i}$ is its equilibrium level. The second term on the right-hand side is the expected deviation of the k-period ahead inflation rate (π) from the target rate (π^*) which is assumed to be constant over time. The third term is the expected deviation of the k-period ahead level of output (y) from its natural level (y^*) (i.e., the output gap). The coefficients α_1 and α_2 represent the intensity with which the desired interest rate of the central bank reacts to the inflation and the output gap. The assumption of interest rate smoothing behavior then leads to:

$$i_t = (1 - \rho) i_t^* + \rho i_{t-1} + \nu_t, \tag{2}$$

where the parameter ρ (with $0 < \rho < 1$) describes the degree of interest rate smoothing and ν_t represents an i.i.d. exogenous random shock to the interest

[1] See Hamalainen (2004) for a survey of empirical studies related to the USA.

rate. Combining (1) and (2) leads to:

$$i_t = (1-\rho)(\bar{i} + \alpha_1 E_t(\pi_{t+k} - \pi^*) + \alpha_2 E_t(y_{t+k} - y^*_{t+k})) + \rho i_{t-1} + \nu_t \quad (3)$$

Equation (3) represents the econometric specification which is commonly used to describe the central bank behavior. Since the right-hand side of equation (3) includes expectations that are not directly observable it is common to substitute them by the observed ex-post levels of the respective variables and rearrange the estimation equation into a form that contains the expectation errors of the central bank in the error term. Then this form is mostly estimated by General Methods of Moments. Equation (3) becomes the plain Taylor rule when ρ is assumed to be zero and the horizons of the forward-looking behavior of the central bank, k, is set equal to zero. In order to precisely describe the information set of the central bank, Orphanides (2001a) estimates the Taylor rule on the basis of real-time data instead of ex-post revised data. He finds significant differences when taking real-time data into account.

The main message generated by empirical studies focusing on the G7 central banks can be summarized as follows. First, forward-looking specifications seem to fit the central bank's behavior better than contemporaneous versions. Here the forward-looking feature is most relevant for the inflation gap with the horizon (k) being about one year. Second, the relevance of the *Taylor principle* for stability, i.e., a reaction coefficient for inflation being greater than unity, is well demonstrated and its presence is a strong feature of the more recent monetary policy. Third, the reaction coefficient for the output gap is mostly significant but has a significant lower value compared to the inflation gap coefficient.[2] Fourth, persistence in the central bank's interest rate is a strong feature in the data. However, it is not yet clear whether this is due to intended interest rate smoothing by the central bank

[2]In particular, for the output gap the literature emphasizes that it is relevant to discriminate between ex-post and real-time data (Orphanides, 2001a,b).

or whether it is due to a strong autocorrelation in the shocks upon which monetary policy reacts.[3]

Our analysis takes the afore-mentioned four core results of Taylor-type rules as its starting point and interprets them as (historical) information on the central bank's behavior that is available for financial market participants. If the latter believe in the Taylor-type rule as a valid description of the central bank interest rate setting behavior we would expect to observe this in their simultaneous forecasts of the short-term interest rate, the inflation rate and output changes.[4] In this case, the forecasts of the three variables can hardly be independent of each other. They rather should display the same links and dependencies as suggested by the estimated reaction functions. We therefore estimate variants of equation (3) based on reported forecasts of financial market participants, i.e., ex-ante data. Before we present the results in section 4, the subsequent section briefly introduces our data set.

3 Survey studies and data

We use survey data from the Consensus Economic Forecast poll. This survey regularly asks professional forecasters about their projection of several financial and real economy variables such as interest rates, unemployment rates and GDP growth. The data set has several advantages over other surveys and is, thus, less subject to some of the weaknesses often associated with survey data. First, the individual forecasts are published together with the names of the forecasters' company. As this allows everybody to evaluate the performance of the company, the goodness of the forecasts can be expected

[3]Since this issue is not of a strong concern in the present paper, we refer to the recent literature. See, for instance, Rudebusch (2006).

[4]It needs to be emphasized that we do not claim that financial market participants, explicitly forecast the interest rate using Taylor-type rules. It could also be the case that they implicitly use this type of monetary policy rule as a reduced form. However, both cases yield forecasts which are internally consistent with Taylor-type rules.

to have an effect on the reputation of the forecasters.[5] This is expected to increase the incentives of the survey participants to submit their best rather than their strategic forecast (see Keane and Runkle 1990).[6] Second, unlike some other surveys, forecasters participating in the Consensus Economic Forecast poll do not only submit the direction of the expected change of the macroeconomic variable, but forecast a specific level which allows for more differentiation between individual forecasts. Third, the survey data are readily available to the public so that our results can easily be verified. By the same token we argue that the forecasts reflect the financial market expectations.[7] Since analysts are bound in their survey answers by their recommendations to clients an analyst may find it hard to justify why he gave a recommendation different to the one in the survey. Fourth and finally, our data set covers a period of more than 18 years and, hence, provides evidence invariant to business cycle considerations.

Survey data so far only entered Taylor rules as expected inflation rates on an aggregated level. Reade (2006), for instance, uses monthly data of the University of Michigan survey to estimate Taylor rules for the Fed in a cointegrated VAR model. Using real-time data he provides support for the Taylor rule literature. Romer and Romer (2002) use the Livingston survey

[5]Batchelor (2001) shows that the Consensus Economics forecasts are less biased and more accurate in terms of mean absolute error and root mean square error compared to OECD and IMF forecasts. He also shows that there is little information in the OECD and IMF forecasts that could be used to reduce significantly the error in the private sector forecasts. Mitchell and Pearce (2007) analyze individual forecasts of Wall Street Journal economists'. They find that a majority of the professional forecasters produced unbiased interest rate forecasts, but the forecasts are indistinguishable from a random walk model and the economists are systematically heterogeneously distributed.

[6]In contrast to the view of Keane and Runkle (1990), Laster et. al (1999) develop a model in which forecasters are rewarded for forecast accuracy in statistical terms as well as by publicity in case of giving the best forecast at a single point in time. As a consequence those forecasters will differ the most from consensus forecast whose wages depend the most on publicity.

[7]The participants of the poll are working for investment banks, commercial banks and consultancies. Appendix A reports a complete list of the institutions participating in the Consensus Economic Forecast poll.

to compare inflation expectations with a simple forward-looking monetary-policy rule. Their results suggest that the monetary policy of the Fed differs between the sample periods. However, Reade (2006) and Romer and Romer (2002) only use the mean of the poll, whereas the Consensus Economic Forecast poll which is used in this paper contains individual data of over 300 business experts, which allows us to analyze the forecasts for each professional forecaster.[8]

Berger et. al (2006a) investigate the accuracy of professional forecasts on the ECB monetary policy rate compiled in the Reuters survey. A first result is that the systematic heterogeneity in the poll can be attributed to geography. Forecasters headquartered near the ECB outperform the sample average as well as forecasters located in countries with an independent central bank. As a second result, Berger et. al (2006a) find no tendency of learning of the forecasters, as the heterogeneity apparently does not decline over time. In a related study, Berger et. al (2006b) find that the forecast accuracy of Fed watcher's depends on geography and skill, such as job position and education.

Our study investigates whether professional forecasters apply Taylor-type rules in their forecasts. Using the monthly Consensus Economic Forecast poll of the G7 countries, we examine the time period between October 1989 and December 2007 covering 220 periods. The sample period ends in December 2007 to neglect the recent financial developments of the international financial crisis. The number of professional economists participating in the survey is the highest for the UK (75 forecaster) and the lowest for Canada (39 forecaster). In order to investigate the time series characteristics of the expectation formation process of the participants, we only include professional forecasters who participated in the survey at least ten times during

[8]Giordani and Soederlind (2001) point out that individual survey data on expectation are preferable to time series models, especially when forecast uncertainty is high. Using quarterly data, they analyze the uncertainty of U.S. inflation and real output growth forecasts of the Survey of Professional Forecasters and find that forecaster seem to underestimate uncertainty.

the period October 1989 – December 2007.[9] This applies, for instance in the case of the UK, to a total of 66 participants and yields over 5,000 forecasts for each variable, i.e., the expected three month interest rate, the expected Consumer Price Index (CPI) and the expected growth rate of the real Gross Domestic Product (GDP).

Moreover, the professional forecasters are requested to predict the interest rates for two different time horizons, namely for the next three months and the following twelve months. Using these alternative time horizons we distinguish between a short-term and medium-term Taylor rule. Forecasts of the GDP and CPI are provided for the current and next year. In order to keep the forecast horizon constant (i.e., three and twelve months) we construct a weighted average of the GDP and CPI forecast as described in Appendix B.

Table 1 provides an overview of the data set and summarizes its main features. Table 1 also shows that the expectations on the macroeconomic variables were on average a good predictor for the future actual value. For instance, for Japan the average forecasts for the interest rate (1.70 percent) and inflation rate (0.55 percent) are close to the actual average values of 1.72 and 0.55 percent, respectively. Only for Germany the mean interest rate forecasts (5.97 percent) differ noticeably from the actual mean (7.01 percent). However, this does not imply that all forecasts are unbiased for each point in time, but we leave the discussion of the accuracy of the forecasts to further research.

– Insert Tables 1 about here –

A potential drawback of our analysis is that the Taylor rule is suggested to work for the central bank's lending rate. Since our data set consists of three months interest rate forecasts this might contradict our analysis. However, Table 2 shows that the correlation coefficients between the actual

[9]Due to the introduction of euro in January 1999 the sample period for France, Germany and Italy ends in December 1998.

three months interest rate and the central bank's interest rate for the G7 countries are about 0.99. Moreover, we potentially would find even stronger evidence in favor of the Taylor rule in financial market expectations if we could observe expectations on the central bank's lending rate instead of the three months interest rate.

– Insert Tables 2 about here –

4 Estimation results for 'ex-ante' Taylor-type rules

For our empirical analysis we start from the econometric specification of the Taylor rule as derived in section 2:

$$i_t = (1-\rho)(\bar{i} + \alpha_1 E_t(\pi_{t+k} - \pi^*) + \alpha_2 E_t(y_{t+k} - y^*_{t+k})) + \rho i_{t-1} + \nu_t \quad (3)$$

The most difficult variable to quantify in this framework is the expected output gap $E_t(\tilde{y}_{t+k})$. In line with Clarida et al. (1998), we take the industrial production index for the G7 countries and take the expected growth rate to measure the expected contribution to the industrial production $E_t(\Delta y_{t+k})$ for the period $t+k$. To calculate the output trend y^*_{t+k} we apply a standard Hodrick–Prescott filter (with the smoothing parameter set at $\lambda = 14{,}400$) and define the expected output gap as $E_t(\tilde{y}_{t+k}) = y_t + E_t(\Delta y_{t+k}) - y^*_{t+k}$.[10]

In order to arrive at a testable relationship, the unobservable terms in equation (3) have to be eliminated. Since the data set we use allows us to directly observe expectations on the short-term interest rate, the inflation rate and output changes, we only lack information on the equilibrium interest

[10] Hence, the expected output gap consists of the observable output, the expected output change, and the output trend. Since information of the current output is frequently published with a certain time lag and sometimes revised, Orphanides (2001) uses real-time, i.e data available at the respective point in time. However, using real-time data from the OECD database for the G7 countries does not change our results qualitatively. Results are available upon request.

rate and the inflation target of the respective central bank. Consistent with Clarida et al. (1998), we treat these two variables as time-invariant and aggregate both of them into the constant.[11] Thus, we rewrite equation (3) as:

$$E_t i_{t+q} = (1-\rho)\alpha_0 + \alpha_1(1-\rho)E_t\pi_{t+k} + \alpha_2(1-\rho)E_t(\tilde{y}_{t+k}) + \rho i_t + \epsilon_t \quad (4)$$

where

$$\alpha_0 = \bar{i} - \alpha_1 E_t \pi^*. \quad (5)$$

In equation (4) we already use the expected interest rate forecast as left-hand side variable. In the subsequent regressions we look at two different forecast horizons. We employ three months forecasts of the three months interest rate as the left-hand side variable when referring to the short-term forecast. For the medium-term forecast we employ the twelve months forecasts of the three months interest rate as the dependent variable. Note that we do not need to apply the General Methods of Moments when estimating equation (4), since all expectational variables on the right-hand side are also observed data. Thus, we rely on OLS in our panel setting. However, our econometric analysis is impaired by the problem of overlapping forecast horizons since the monthly data set provides three months forecasts. This obviously leads to serial correlation in the error terms by construction. In order to overcome the problem of serial correlation in the error terms due to overlapping forecast horizons, we apply a serial correlation model:

$$\epsilon_{t,i} = \beta_i \epsilon_{t-1,i} \quad (6)$$

where the autoregressive term β_i measures the degree of persistence in the error term. Additionally, we use Prais-Winsten panel corrected standard errors to account for cross section correlation among the survey participants.

[11] However, relaxing the assumption of a time-invariant long-term inflation target π^* requires an appropriate time-variant measure for π^*_t. We leave this to further research.

Table 3 displays the results of estimating equation (4). The short-term and medium-term regressions are contemporaneous versions, i.e., all variables enter with the same time index. The short-term equation (called 'Short') regresses the three months interest rate forecast on the forecasts of inflation and output growth for three months (i.e., $q = k = 3$). The medium-term regression (called 'Medium') uses forecast horizons of twelve months forecasts for all variables instead (i.e., $q = k = 12$). The lagged interest rate is the actual (observable) three months interest rate.[12] In the forward-looking specification (called 'Forward') the dependent variable is the three months interest rate forecasts (i.e., $q = 3$) while the independent variables reflect twelve months forecasts (i.e., $k = 12$). This implies that the monetary policy is expected to affect the inflation rate and GDP growth with a time lag of nine months. Against the background that the time-lag of the monetary policy is about nine to twelve months, the forward-looking specification fits the central bank reaction function very well.

Evaluating the estimations in Table 3 five findings stand out:

1. For the short-term and the forward-looking version the interest rate forecasts are highly dominated by the actual rate which is indicated by a large smoothing parameter (ρ) between 0.54 (Italy, forward-looking version) and 0.99 (Germany, short-term version). In the latter case, the smoothing coefficient is not different from unity and renders the results in that specification. The high persistence in the interest rate forecast could well be due to the aftermaths of the German reunification and the subsequent response of the Deutsche Bundesbank. Apparently, the financial market sticked to the current interest rate instead of expecting the Deutsche Bundesbank to respond to inflation

[12] More precisely, as the actual interest rate we use the average of the respective month in order to avoid daily volatility effects. However, our results do not qualitatively change using the interest rate at the beginning or the end of the month. Results can be obtained on request.

or output changes.[13] Although the remaining smoothing parameters estimated in our model are statistically smaller than unity, some are very close to unity.[14] However, the high value of the smoothing parameter has also been documented in the literature that analyzes the actual central bank behavior.[15] The medium-term forecasts, however, exhibit a smaller degree of smoothing ranging from 0.27 (France) to 0.81 (Japan), which is quite intuitive given the longer forecast horizon of twelve months and the likely perception that smoothing refers to avoiding pronounced short-term fluctuations. Hence, interest rate forecasts for the three months horizon should exhibit a higher persistency compared to twelve months forecasts.

2. The inflation coefficient (α_1) is positive for all specifications and countries. In the short-term version, the inflation coefficient is of reasonable size and in line with the *Taylor principle* in the cases of France, Italy, and the UK. For Germany and the USA the inflation coefficient is not statistically different from unity. In the forward-looking version the *Taylor principle* holds for all countries except for Canada, Germany and Japan where α_1 is not statistically different from unity. In the medium-term version the inflation coefficient (α_1) is not significantly different from unity for France, Japan, the USA while for Italy the *Taylor principle* holds. Put differently, in the medium-term version financial market participants it is less likely that the financial market

[13] This might also explain the noticeable interest rate forecast error shown in Table 1.

[14] This finding matches the well-demonstrated phenomenon that short-term expectations in financial markets are rather static than dynamic (Mitchell and Pearce, 2007). Furthermore, Krueger and Kuttner (1996) found that the Federal Funds future market provide efficient predictions on the future path of the Funds rate. As the future and actual path of the Funds rate are close to each other, static expectations seem reasonable as a means to forecast interest rates.

[15] Using the same model set up but applying actual instead of expected values on the right hand side of equation (4), in principle, Clarida et al. (1998) estimate the G7 central banks' reaction function for the period between 1979 and 1993 and report similar smoothing parameters of about 0.92.

expects the *Taylor principle* to hold.[16]

3. For all countries and in all specifications the output coefficient (α_2) has the expected sign and is of reasonable magnitude. The expected output coefficient is highest for the UK (0.63, forward-looking version) and lowest for Germany (0.03, in the medium-term version).

4. The results reported in Table 3 basically support our choice of model specification. The coefficient of the autoregressive error term ranges between 0.54 (Japan) and 0.92 (France). Hence, the application of a serial correlation model seems to be appropriate. Moreover, the overall coefficients of determination suggest a high explanatory power of the regression model.

5. Table 3 reports for Japan that in the medium-term and forward-looking version the inflation coefficients are not distinguishable from unity. This implies that the financial market expects the real interest rate to remain unchanged over the sample period. This at the first glance odd result is probably due to the severe monetary crisis in Japan during the 1990, in which low interest and inflation rates coincided and the monetary policy of the Bank of Japan was regarded as being ineffective (Westermann and Hutchinson, 2006). In order to avoid the problems due to the monetary crisis in Japan we estimate the expected Taylor rule for the time period before and after the monetary instability. Table 3 shows the results excluding the period 1991 till 2003.[17] The results are now comparable to those for the other G7 central banks reported in Table 3. The *Taylor principle* holds for Japan. Interestingly, the

[16] Davig and Leeper (2007) argue that an inflation coefficient less than unity can be due to a temporary regime switch from active to passive monetary policy. As a result the *Taylor principle* does not necessarily be higher than unity.

[17] We choose to skip the years 1991 till 2003 to avoid the aftermaths of the monetary crisis in Japan. However, the results are robust against other windows and available upon request.

output coefficient is ambiguously indicating that the financial market does not expect the Bank of Japan to successfully fight the period of low GDP growth.

– Insert Tables 3 about here –

In sum, this section provides evidence that financial market forecasts are internally consistent with Taylor-type rules at least in the forward-looking version which is also the preferred specification of the Taylor rule in the framework of central bank reaction functions. In the short-term (medium-term) version expectations the *Taylor principle* is violated for one (three) central banks indicating that for longer forecasts financial market participants apply the Taylor rule framework to a lesser extent. Additionally, we find that the output coefficient and the smoothing parameter have the expected sign and are of reasonable magnitude compared to the results reported by Clarida et al. (1998). The next section advances the analysis and examines whether the long-term inflation target inherent in financial market forecasts is in line with the actual long-term inflation rate.

5 The long-term (expected) inflation rate

The estimation procedure allows us to investigate another feature inherent in the Taylor rule, i.e., the expected long-term inflation rate ($E\pi^*$). In order to recover the expected inflation target we use the parameter estimates α_0 and α_1 from Table 3 reporting the estimates of equation 4. Recall that

$$\alpha_0 = \bar{i} - \alpha_1 E_t \pi^* \tag{5}$$

and given the Fisher relation

$$\bar{i} = i^{real} + E\pi^* \tag{7}$$

which together yields

$$\alpha_0 = i^{real} + (1 - \alpha_1) E\pi^*. \tag{8}$$

This implies that

$$E\pi^* = \frac{\alpha_0 - i^{real}}{1 - \alpha_1}. \tag{9}$$

Like Clarida et al. (1998) we use the expected sample average real interest rate among all individuals to provide an estimate of i^{real}. With these estimates it is possible to construct the expected target inflation rate $E\pi^*$ by the means of the medium-term results shown in Table 3.[18]

Table 4 shows the expected real interest rate, the long-term inflation rate and the actual inflation rate. The expected real interest rate is of considerable size for the majority of the G7 countries. Additionally, Table 4 reports the expected inflation targets and the average inflation rate for the sample period 1989 – 1998 and 1989 – 2007, respectively. For instance, only for the UK the expected long-term target inflation rate (3.67) is very close to the actual inflation target (3.35). Additionally, Table 4 reports the values of a t-test comparing expected and actual inflation rates. The expected long-term target inflation rate (Eπ^*) significantly differs from the actual average inflation rate (π^{act}) only for Germany and Italy. For the remaining five countries the expected long-term inflation rate is not statistically different from the actual average inflation rate. In the cases of Japan and USA this result is probably due to the considerably high standard error. However, considering the period excluding the years of financial instability in Japan, the expected long-term inflation rate is not statistically different from the average inflation rate, but the standard error has decreased. In sum, Table 4 provides evidence that at least for the majority of G7 countries the expected long-term inflation target, based on the forecasts of the financial market, is not statistically different from the actual inflation rate.

[18] We use the medium-term specification since it reflects the specification with the longest forecast horizon, i.e., twelve months. Another reason is that, it is defined as a contemporaneous version which implies that the interest and inflation forecasts have the same maturity. In this setting this feature is crucial and hence, preferable to the forward-looking version since this yields a real interest rate forecast with the same maturity.

– Insert Tables 4 about here –

6 Conclusion

This paper uses a unique data set on financial market forecasts to investigate whether the financial market believes in and, thus, applies Taylor-type rules in their forecasts for the G7 countries over the period 1989 – 2007. While the literature has so far focused on revised or real-time data, our approach takes ex-ante data into consideration. Therefore, we use the Consensus Economic Forecast poll which contains individual interest, inflation and growth rate forecasts. We find that interest rate forecasts are, indeed, internally consistent with the message of Taylor-type rules for all G7 countries at least in the forward-looking version. In the case of Japan we obtain this result when neglecting the period of monetary instability. Moreover, we find that the financial market expects a long-term inflation target which is not different compared to actual average inflation rate. We take this feature as additional evidence that the financial market applies Taylor-type rules to forecast short-term interest rates.

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Table 1: Forecasted and Actual Mean of Variables of the Data Set

Country	France	Germany	Italy	Canada	Japan	UK	USA
		1989 - 1998			1989 -2007		
Interest Rate Forecasts							
Short-term	6.59	5.97	6.45	5.12	1.70	6.65	4.37
Medium-term	6.12	5.77	6.27	5.27	1.79	6.58	4.70
Actual Interest Rate OECD	6.99	7.01	6.12	5.27	1.72	6.69	4.68
CPI Forecasts							
Short-term	2.27	2.68	3.32	2.33	0.55	3.12	2.90
Medium-term	2.38	2.68	3.03	2.34	0.63	3.08	2.87
Actual CPI Growth IMF	2.35	2.57	3.50	2.22	0.55	3.38	2.91
Real GDP Growth Forecast							
Short-term	2.00	1.78	1.62	2.59	1.63	2.01	2.76
Medium-term	2.20	1.91	1.82	2.73	1.68	2.17	2.74
Actual Growth Rate IMF	2.06	1.84	1.60	2.59	1.78	2.37	2.77
Real Interest Rate Forecast							
Short-term	4.31	3.29	5.16	2.80	1.16	3.55	1.48
Medium-term	3.79	3.08	4.68	2.96	1.23	3.51	1.84

Notes: Table 1 shows the expected and the actual mean of the variables over the sample period October 1989 – December 1998 (December 2007).

Table 2: Correlation Coefficients for the Three Months Interest Rate and the Central Bank's Interest Rate

Country	France	Germany	Italy	Canada	Japan	UK	USA
Period		1989 – 1998			1989 – 2007		
Central Bank Interest Rate	6.85	5.43	9.90	5.39	1.35	6.55	4.59
Three Months Interest Rate	7.01	6.13	9.89	5.27	1.72	6.69	4.68
Correlation	.99*	.93*	.99*	.99*	.99*	.99*	.99*

Notes: Table 2 shows the mean of the three months and funds rate for the respective central bank; the Bravais-Pearson correlation coefficient measures the correlation of the three months interest rate and the Funds rate over the sample period October 1989 – December 1998 (– December 2007); * indicates significance of the correlation coefficient on a one percent level.

Table 3: Estimation Results for the 'Ex-ante' Taylor-Type Rules

Country		α_0	α_1	α_2	ρ	β	$\alpha_1 > 1$	$\alpha_2 > 0$	R^2	Obs.	Groups
	Short	2.50*	.81*	.30*	.86*	.60*	.98	.00	.97	3,167	33
		(.13)	(.09)	(.05)	(.01)						
Canada	Medium	3.85*	.70*	.11*	.52*	.84*	.99	.00	.89	3,013	33
		(.11)	(.06)	(.02)	(.02)						
	Forward	1.95*	1.07*	.18*	.84*	.63*	.22	.00	.97	3,019	33
		(.12)	(.09)	(.04)	(.01)						
	Short	.69*	2.21*	.17*	.61*	.70*	.00	.00	.96	1,688	25
		(.07)	(.09)	(.03)	(.01)						
France	Medium	3.40*	.91*	.09*	.27*	.92*	.21	.00	.91	1,589	25
		(.20)	(.07)	(.01)	(.02)						
	Forward	.56*	2.14*	.25*	.63*	.65*	.00	.00	.96	1,594	25
		(.22)	(.10)	(.02)	(.01)						
	Short	29.82	-19.19	3.21	.99*	.52*	.76	.78	.99	2,410	33
		(41.38)	(29.73)	(4.34)	(.01)						
Germany	Medium	3.53*	.66*	.03*	.56*	.90*	.99	.00	.88	2,358	33
		(.17)	(.09)	(.01)	(.02)						
	Forward	1.81*	.71*	.29*	.93*	.58*	.86	.00	.99	2.364	33
		(.32)	(.27)	(.05)	(.01)						
	Short	.40*	1.99*	.08+	.54*	.54*	.00	.01	.95	992	20
		(.13)	(.06)	(.04)	(.02)						
Italy	Medium	.78*	1.76*	.09*	.40*	.69*	.00	.00	.94	973	20
		(.08)	(.06)	(.03)	(.02)						
	Forward	.09	2.10*	.01	.56*	.54*	.00	.16	.96	994	20
		(.27)	(.06)	(.03)	(.02)						
	Short	1.02*	.60*	.14*	.95*	.54*	.98	.00	.99	3,514	39
		(.09)	(.16)	(.04)	(.00)						
Japan	Medium	1.59*	1.08*	.03+	.81*	.74*	.17	.02	.98	2,733	39
		(.07)	(.08)	(.02)	(.01)						
	Forward	.81*	.96*	.07+	.94*	.56*	.60	.02	.99	2,891	39
		(.08)	(.16)	(.03)	(.00)						
	Short	1.77*	1.60*	.10	.96*	.53*	.04	.18	.99	915	33
Japan		(.38)	(.35)	(.11)	(.01)						
	Medium	1.19*	1.32*	-.01	.83*	.60*	.00	.55	.99	683	32
(w/o crisis)		(.12)	(.17)	(.05)	(.02)						
	Forward	1.32*	2.08*	-.07	.95*	.57*	.00	.76	.99	724	32
		(.28)	(.31)	(.10)	(.01)						
	Short	2.57*	1.24*	.41*	.91*	.56*	.00	.00	.98	5,586	66
		(.14)	(.06)	(.07)	(.01)						
UK	Medium	5.00*	.59*	.10*	.67*	.84*	.99	.00	.91	5,405	66
		(.16)	(.05)	(.02)	(.01)						
	Forward	1.80*	1.24*	.63*	.94*	.54*	.01	.00	.99	5,394	66
		(.19)	(.11)	(.09)	(.01)						
	Short	-.24*	.98*	.20*	.86*	.66*	.59	.00	.97	2,727	34
		(.10)	(.09)	(.05)	(.01)						
USA	Medium	2.34*	.94*	.14*	.70*	.80*	.75	.00	.89	2,526	34
		(.11)	(.08)	(.03)	(.02)						
	Forward	-.85*	1.21*	.08+	.86*	.66*	.02	.01	.97	2,548	34
		(.12)	(.10)	(.03)	(.01)						

Notes: Estimated equation (4) $E_t i_{t+q} = (1-\rho)\alpha_0 + \alpha_1(1-\rho)E_t\pi_{t+k} + \alpha_2(1-\rho)E_t(y_{t+k} - y^*_{t+k}) + \rho i_t + \epsilon_t$ by the means of a serial correlation model where $\epsilon_{t,i} = \beta_i \epsilon_{t-1,i}$; the sample period ends in December 1998 for France, Germany and Italy, and ends in December 2007 for the remaining countries; to estimate Japan (w/o crisis) we skip the time period 1991 – 2003; values in parentheses present panel corrected standard errors applying the Prais-Winsten model; following the Hausman test we either use the fixed-effects or random-effects estimator; $\alpha_1 > 1$ ($\alpha_0 > 0$) is a Chi^2 test on the null hypothesis that $\alpha_1 \leq 1$ ($\alpha_0 \leq 0$); the R^2 refers to the overall coefficient of determination; within and between R^2 are skipped from Table 3 for readability but available upon request; * (+) indicates significance at the one (ten) percent level, respectively.

Table 4: Expected Long-Term Inflation Target Rates and Actual Inflation Rates

Country	Canada	France	Germany	Italy	Japan	(w/o crisis)	UK	USA
Expected Real Interest Rate ($\bar{E}(i^{real})$)	2.96	3.79	3.08	4.68	1.23	1.36	3.51	1.84
Implied Inflation Rate ($E\pi^*$)	2.96	-4.25	1.33	5.11	-4.74	0.53	3.67	8.81
	(.58)	(5.26)	(.58)	(.30)	(5.43)	(.27)	(.49)	(12.19)
Actual Inflation Rate (π^{act})	2.22	2.35	2.57	3.50	0.57	0.70	3.35	2.92
Test: $\pi^* = \pi^{act}$	.21	.21	.02	.00	.33	.55	.51	.63

Notes: The expected real interest rate is the average of the real interest rate forecast over the sample period 1989 – 2007; the expected inflation rate is calculated by the means of (4) $E\pi^* = \frac{\alpha_0 - i^{real}}{1-\alpha_1}$ based on the estimation results of Table 3; the sample period ends in December 1998 for France, Germany and Italy, and ends in December 2007 for the remaining countries; to estimate Japan (w/o crisis) we skip the time period 1991 – 2003; standard errors in parenthesis; the actual inflation rate π^{act} reflects the average inflation rate as displayed in Table 1; the last row reflects the significance level of a two-sided t-test under the null hypothesis that the expected long-term inflation rate equals the actual average inflation rate.

Appendix A: List of Participants in the Consensus Economic Forecast Poll by Country

Canada	France	Germany	Italy	Japan	UK		USA
Bank of Montreal	Bank of America	Bank Julius Baer	Banca Commerciale	Bank of Tokyo	ABN Amro	ING Financial Markets	Amoco
Bank of Nova Scotia	Banque D'Orsay	Bank Liechtenstein	Banca di Roma	Baring Securities	Barclays Bank	ITEM Club	Bank of America
Bunting Warburg	Banque Paribas	Bankgesellschaft Berlin	Banca Intesa Cariplo	BZW	Barclays Capital	James Capel	Bank One Corp
Burns Fry	BFCE	Bayerische LB	Bank of America	CSFB	Barclays de Zoete	JP Morgan	Bankers Trust
Caisse de Depot	Caisse des Depots	Bayerische VB	Cariplo SpA	Dai-Ichi Kangyo Bank	Baring Brothers	Kleinwort Benson	Bear Stearns
Canadian Imperial	Chambre de Commerce	Citibank	Centro Europe Ricerche	Daiwa Institute	Beacon Econ Forecasting	LBS	Bethlehem Steel
CIBC	CPE	Commerzbank	Chase Manhattan	Deutsche Bank	British Telecom	Lehman Brothers	Chase Manhattan
Conference Board	Credit Agricole	Delbruck & Co	Confindustria	Dresdner Kleinwort	Business Strategies	Liverpool Macro	Continental Bank
Desjardins	Credit Comm de France	Deutsche Bank	Credito Italiano	Fuji Research Institute	Cambridge Econometrics	Lloyds	CRT Govt.
Dominion Securities	Credit National	Dresdner Bank	Deutsche Bank	Global Insight	Capital Economics	Lombard Street	CSFB
DRI Canada	Deutsche Bank	Dt. Girozentrale	ENI	Goldman Sachs	Chase Manhattan	Merrill Lynch	Daimler Chrysler
DuPont Canada	Econ Intelligence Unit	DZ Bank	Euromobiliare	HSBC	Citibank	Midland Bank	Dun & Bradstreet
Economap	Gaz de France	FAZ InfoDienste	Fiat SpA	Industrial Bank of Japan	Citicorp Scrimgeour	Morgan Guaranty	DuPont
EDC Economics	HSBC	Hessische LB	Instituto Bancario	ITOCHU Institute	City University	Morgan Stanley	Eaton Corporation
Global Insight	IXIS	Hypo Bank	IRS-REF	Japan Center	Confed of British Industry	National Westminster	Economy.com
Gundy	JP Morgan	IFO	JP Morgan	Jardine Fleming	County Nat West	NIESR	Fannie Mae
Informetrica	Morgan Guaranty	IfW	Prometeia	JP Morgan	Credit Lyonnais Secs	Nomura Securities	First Chicago
JP Morgan	Natexis Banque	Industrie Kreditbank	Salomon SB Citibank	Long Term Credit Bank	CSFB	Norwich Union	First Union Corp
Levesque Beaubien	OFCE	ING	Studi Finanziari	Merrill Lynch	Deutsche Bank	Oxford Economics	Georgia State Uni
McLean McCarthy	Societe Generale	Invesco Bank	UniCredit	Mitsubishi Bank	Deutsche Morgan	Panmure Gordon	Global Insight
Merrill Lynch Canada		JP Morgan		Mitsubishi Research	DRI	RBC Dominion	Goldman Sachs
National Bank		Landesbank Berlin		Mizuho Institute	DTZ Research	RBS Financial Markets	Griggs & Santow
National Bank Financial		Merrill Lynch		Morgan Stanley	Economic Perspectives	Robert Fleming Secs	JP Morgan
Nesbitt Burns		MM Warburg		Nikko Citigroup	Experian Business	Royal Bank of Scotland	Lehman Brothers
Richardson Greenshields		Morgan Stanley		Nippon Credit Bank	Global Insight	Salomon Smith Barney	Macroeconomic Adv.
Royal Bank of Canada		RWI Essen		NLI Research Institute	Goldman Sachs	SBC Warburg	Morgan Stanley
Royal Trust		Sal Oppenheim		Nomura Securities	Greenwell Montagu	Schroder Citibank	Mortgage Bankers
Scotia Economics		SEB		Salomon Brothers Asia	Hambros Bank	SG Warburg	NA Home Buil.
Scotia McLeod		SMH Bank		Salomon Smith Barney	HBOS	SGST Securities	Nations Bank
Sun Life		Trinkaus & Burkhardt		Sanwa Research Institute	Henley Centre	Smith New Court	Regional Financial
Toronto Dominion Bank		UBS Warburg		Schroder Securities	HSBC	UBS	Sears Roebuck
University of Toronto		WestdeutscheLB		SG Warburg - Tokyo	Imperial Chemical Inds	Williams de Broe	Shearson Lehman
Wood		WGZ Bank		Shinsei Bank	Industrial Bank of Japan	Yamaichi	Wachovia Corp
				Sumitomo Life			Wells Capital
				Tokai Bank			
				Toyota Motor			
				UBS Warburg			
				UFJ Institute			
				Yamaichi			

Appendix B: Calculation of the Weighted Average of Expected GDP and CPI

In order to generate a three months forecast we set the forecasted variable f_t at time t (= 1,2,.., 219) equal to the forecast of the current year f_t^{cur} for forecasts collected before November of any year (i.e., the remaining three months are all part of the current year). For forecasts collected in November or December, the three month forecast f_t is calculated as a weighted arithmetic average of the forecast for the current year f_t^{cur} and the next year f_t^{next}. We weight the forecast f_t with the remaining number of months m (with $m = 2$ (for November forecasts) and $m = 1$ (for December forecasts)) at the time of the forecast t:

(A1) $f_t = \frac{f_t^{cur} * m + (3-m) * f_t^{next}}{3}$

In order to generate a twelve months forecast horizon which is consistent with the forecast horizon of the twelve months interest rate forecast we apply the outlined procedure with 1 (= December) $\leq$ m $\leq$ 12 (= January). The twelve months GDP and CPI forecasts f_t are as follows:

(A2) $f_t = \frac{f_t^{cur} * m + (12-m) * f_t^{next}}{12}$

This procedure is also applied by Heppke-Falk and Hüffner (2004) too and Beck (2001). Both studies use data of the Economics Consensus Inc. and construct the arithmetic average as outlined above.