

Expectations, Taylor Rules, and Credibility – Evidence from Four Small Open European Economies with Independent Central Banks

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This paper analyzes the expectation formation process in Denmark, Norway, Sweden and Switzerland. We use the Consensus Economic Forecast poll and show that the forecasts are consistent with Taylor-type rules for three countries but not for Norway. This can be attributed to Norway's long period of an exchange rate targetor. Additionally, we provide evidence that the expected long-term inflation rate is consistent with both the actual average inflation rate and the inflation target for all countries. This implies that the professional forecasters understand the different monetary policy strategies among the four countries indicating that all central banks can be regarded as highly credible.

Keywords: Taylor rule, expectation formation, monetary policy, Scandinavian economies

JEL classification: E52, D84, C33

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This paper analyzes the expectation formation process in Denmark, Norway, Sweden and Switzerland. We use the Consensus Economic Forecast poll and show that the forecasts are consistent with Taylor-type rules for three countries but not for Norway. This can be attributed to Norway's long period of an exchange rate targetor. Additionally, we provide evidence that the expected long-term inflation rate is consistent with both the actual average inflation rate and the inflation target for all countries. This implies that the professional forecasters understand the different monetary policy strategies among the four countries indicating that all central banks can be regarded as highly credible.

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1 Introduction

In his seminal paper John B. Taylor (1993) explains the development of the US short-term interest rate as a simple monetary policy reaction function of the Federal Reserve Bank (Fed). He finds that 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 their target levels. This 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 interest rate adjustments. Such Taylor-type rules have gained significant importance in both monetary theory and policy. Although the structure of Taylor-type rules is simple, it indeed frequently captures the essence of the behavior of the monetary authority. For this reason, 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 early 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 take into account 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 examines whether market participants believe that a central bank follows such a rule. To this end, we apply forecasts, i.e., ‘ex-ante’ data to estimate Taylor-type rules. The unique data set allows us to examine the fundamental question whether professional forecasters apply Taylor-type rules in their forecasts of macroeconomic variables.

Since the Taylor-type rules imply that real output, inflation and the interest rate are linked through a specific relationship, it is possible to check whether the forecasts are internally consistent (i.e., display relationships

known from estimates of Taylor-type rules) or whether they are inconsistent in the sense that financial market participants talk about Taylor rules when describing the observed behavior of a central bank but neglect this reasoning in their joint forecasts of the short-term interest rate, the inflation rate, and output changes. In this paper we, thus, change the perspective from looking at interest rate rules as reaction functions explaining central bank behavior to their revealing whether market participants believe that central banks act in a rule based fashion or whether they conduct monetary policy in a more discretionary way. We refer to this as ‘ex-ante’ Taylor rules. Our analysis, therefore, also touches upon the ‘rules versus discretion’ debate.

The analysis of Denmark, Norway, Sweden and Switzerland is especially appealing, since all countries can be regarded as small open European economies with fairly long history of independent central banks.¹ With the launch of the euro in 1999, Denmark joined the ERM II and introduced an official target zone. Therefore, the monetary policy of the Danmarks Nationalbank follows more or less the ECB monetary policy. Compared to Norway as a formerly exchange rate targeter (Soikkeli, 2002), the Swedish Riksbank and the Swiss National Bank have a long track record as inflation targeting countries. Sweden pursuits an inflation target since 1993 (Riksbank, 2008) and Switzerland introduced it in 1999 (Mishkin and Schmidt-Hebbel, 2006). Both countries target an inflation rate of 2 percent. Hence, it appears interesting to analyze and compare the expectation formation process between these countries. Our study also serves to examine central bank credibility. If a central bank is not expected to comply with its inflation target, the lack of credibility should be reflected in the characteristics of financial markets forecasts.

The paper is structured as follows: The subsequent section 2 briefly reviews

¹In the case of Norway, this is limited to instrument independence rather than goal independence, since the Norwegian government set the monetary policy goal (Soikkeli, 2002).

the concept of Taylor-type rules and the core results that have emerged from the empirical literature. Section 3 describes the data employed in our study and section 4 presents the results. Section 5 investigates whether the long-term inflation target of the respective central bank is reflected in professional forecasts. Finally, section 6 presents a summary and several conclusions.

2 The empirics of Taylor-type rules at a glance

Due to the paper of Taylor (1993), it has become conventional to describe the interest rate setting behavior of central banks in terms of monetary policy reaction functions. In its pure 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 rate 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. Among 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 of industrialized countries can reasonably well be explained by Taylor-type rules.²

²See Hamalainen (2004) for a survey of empirical studies related to the USA.

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

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

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 sensitivity 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:

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

where i is the actual short-term interest rate and 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 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 interest rate policy. 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 to a form that contains the expectation errors of the central bank in the error term. Then, this form is typically estimated by Generalized 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 take into account 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 using real-time data.

The main message generated by empirical studies focusing on central banks of industrialized countries 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 represents a strong feature of the more recent monetary policy. Third, the reaction coefficient of the output gap is mostly significant but has a significant lower value compared to the inflation gap coefficient.³ 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 or whether it is due to a strong autocorrelation in the shocks which monetary policy reacts to.⁴

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 identify this in their simultaneous forecasts of the short-term interest rate, of the inflation rate and of output changes.⁵ In this case, the forecasts of the three variables can

³In particular, for the output gap the literature emphasizes that it is relevant to differentiate between ex-post and real-time data (Orphanides, 2001a,b).

⁴Since this issue is not of a strong concern in the present paper, we refer to the recent literature. See, for instance, Rudebusch (2006).

⁵Note 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

hardly be independent of each other. They should rather 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, we briefly introduce our data set in the subsequent section.

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 survey participants of the poll work with investment banks, commercial banks, and consultancies.⁶ The data set has several advantages over other surveys which makes it 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 may well have an effect on the reputation of the forecasters.⁷ This is expected to increase the incentives of the survey participants to submit their best rather than their strategic forecast (Keane and

are internally consistent with Taylor-type rules.

⁶A complete list of the institutions participating in the Consensus Economic Forecast poll is available upon request.

⁷Batchelor (2001) shows that the Consensus Economics forecasts are less biased and more accurate in terms of the mean absolute error and the 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. On top of that, Dovern and Weisser (2008) provide evidence that the participants in the Consensus Economic Forecast poll provide rational and unbiased inflation and growth forecasts for the G7 countries.

Runkle 1990).⁸ 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. Since analysts are bound in their survey answers by their recommendations to clients, a forecaster 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 12 years and, hence, provides evidence invariant to business cycle considerations.

We use the monthly Consensus Economic Forecast poll of Denmark, Norway, Sweden and Switzerland. The poll started for Denmark in October 1989, for Sweden in January 1995 and for Norway and Switzerland in June 1998. Our sample period ends in December 2008, and, hence, covers 127 months for Norway and Switzerland, 167 months for Sweden and 231 months for Denmark. For Denmark, Consensus Economics only publishes the mean forecast, but the disaggregated data (i.e., per forecaster). Hence, we apply pure time series econometric methods in the case for Denmark while for Norway, Sweden, and Switzerland we use the available disaggregated data set and apply panel econometric methods. 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 seven times.⁹ For Sweden, for instance, a total of 27 economists participated in the poll which yields more than 1,600 forecasts for each variable.

⁸In 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 the consensus forecast whose wages depend the most on publicity.

⁹We also used other minimum participation rates. The results, however, do not qualitatively change; they are available upon request.

Forecasted variables are the expected three-month interest rate, the expected Consumer Price Index (*CPI*), and the expected growth rate of the real Gross Domestic Product (*GDP*).

In the Consensus Economic Forecast poll, the professional forecasters are requested to predict the three-month interest rates for two different time horizons, namely for the next three months and the next 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 the Appendix.

Table 1 provides an overview of the forecasted and actual mean values of variables of the data set. Table 1 also shows that the expectations of the macroeconomic variables were on average a good predictor for the respective future actual values. For instance, for Sweden the average interest rate (4.15 percent) and the average inflation rate forecast (1.68 percent) are close to the actual average values of 4.13 and 1.36 percent, respectively. For Switzerland the average interest rate (1.75 percent) and the inflation rate forecast (1.01 percent) do not noticeably differ from the actual interest rate (1.67 percent) and the inflation rate (.99 percent) either.

Table 1 also reports the test statistic of the Pedroni panel unit root test (Pedroni, 1999, 2004) with the null hypothesis of a unit root.¹⁰ The test indicates that all series are panel stationary. This is a prerequisite to estimate Taylor rule properly in order to avoid the spurious regression problem (Österholm, 2005). Österholm (2005) also advocates the application of forward looking specifications and real-time data. This paper takes both arguments into account since forecasts can also be regarded as a kind of real-time data.

¹⁰In the case of Denmark we use the augmented Dickey-Fuller test (Said and Dickey, 1984) which indicates that the respective series are stationary.

– Insert Table 1 about here –

In Figures 1, 2, and 3 the solid line reflects the actual interest rate, while the dotted lines show the mean of the short-term inflation and interest rate forecast at the time of the forecast. All Figures convey the impression that the mean of the short-term interest rate forecast is close to the actual interest rate series indicating persistence in interest rate forecasts. Figure 1 shows that the interest rate decreased substantially in Norway after the introduction of the inflation target in 2001 while the inflation expectations remain relatively stable below the inflation target of 2.5 percent. For Sweden (Figure 2) the (expected) interest rate moves in line with inflation expectations which already indicates that the Bank of Sweden is expected to respond to expected inflation. Figure 3 shows that – except for the most recent development – the expected inflation rate in Switzerland is below the inflation target of 2 percent.

– Insert Figures 1, 2, and 3 about here –

Exemplarily, Figures 4, 5, and 6 show the individual short term GDP growth, inflation rate and interest rate forecasts for Sweden.¹¹ The Figures show that there is a substantial degree of heterogeneity among the forecasters. For instance, in January 1995 the GDP growth (interest rate) forecasts range between 1.1 and 3.3 (8.4 and 9.0). At the same time the inflation rate forecasts for 1995 vary between 2.9 and 5.5 which reflect at least some heterogeneity among the survey participants.

– Insert Figures 4, 5, and 6 about here –

¹¹For clarity we only present forecasts made in January, but forecasts published in other months show similar patterns.

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 $E_t(y_{t+k} - y_{t+k}^*)$. In line with Clarida et al. (1998), we take the industrial production index and 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 $E_t(\tilde{y}_{t+k}) = y_t + E_t(\Delta y_{t+k}) - y_{t+k}^*$.¹²

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 rate. For the expected inflation target we do have information, but due to the fact that it was constant for the countries under consideration and its inclusion would only change the constant term, we proceed in different way. We treat it as unknown and extract the expectations on the inflation target from the estimation results. This enables us to test whether the expected target is in line with the official inflation target. Again, consistent with Clarida et al. (1998), we treat the equilibrium interest rate and the inflation

¹²Hence, 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 (2001a) uses real-time, i.e data available at the respective point in time. However, using real-time data from the OECD database does not change our results qualitatively. The results are also robust using the the real growth forecasts rather than calculating the expected output gap. All results are available upon request.

target as time-invariant and aggregate them into the constant. Thus, we rewrite equation (3) as:

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

where q is the forecast horizon of the interest rate of forecaster j and

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

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-month forecasts of the three-month interest rate as the left-hand side variable when referring to the short-term forecast. For the medium-term forecast we employ the twelve-month forecasts of the three-month interest rate as the dependent variable. Note that we do not need to apply the Generalized 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-month 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:

$$\epsilon_{t,j} = \beta_j \epsilon_{t-1,j} \quad (6)$$

where the autoregressive term β_j 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.

Table 2 displays the results of estimating equation (4).¹³ The short-term and medium-term regressions are contemporaneous versions, i.e., all

¹³Since Consensus Economics only publishes the mean instead of the individual data for Denmark we estimate equation (4) by means of a ARIMA (0,0,3) model. We use three lags, since the short-term interest rate forecast covers a time period of three month. However, the results are robust against the application of other lag structures or different estimators.

variables enter with the same time index. The short-term equation (called ‘Short’) regresses the three-month 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-month forecasts for all variables (i.e., $q = k = 12$). The lagged interest rate is the actual (observable) three-month interest rate.¹⁴ In the forward-looking specification (called ‘Forward’) the dependent variable is the three-month interest rate forecast (i.e., $q = 3$), while the independent variables reflect twelve-month forecasts (i.e., $k = 12$). This implies that monetary policy is expected to affect the inflation rate and GDP growth with a time lag of nine months. Against the background of an expected time-lag of the monetary policy of about nine to twelve months, the forward-looking specification fits the central bank reaction function very well.

When evaluating the estimations in Table 2, three findings stand out. First, 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 .85 (Switzerland, short-term version) and .93 (Sweden, short-term version).¹⁵ The high value of the smoothing parameter has also been documented in the literature that analyzes the *actual* central bank behavior (Clarida et al., 1998). The medium-term forecasts, however, exhibit a smaller degree of smoothing ranging from .54 (Norway) to .76 (Sweden), which is quite intuitive given the longer forecast horizon of twelve months and the likely perception that smoothing refers to avoiding

¹⁴More 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 upon request.

¹⁵This 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.

pronounced short-term fluctuations. Compared to the panel econometric results, the time series results in the case of Denmark show smaller smoothing coefficients.

Second, the inflation coefficient (α_1) is consistently positive and greater than unity for Denmark, Sweden and Switzerland (only in the forward specification) which is in line with the *Taylor principle* indicating that if inflation expectations increase by one percent, the interest rate is expected to increase by more than one percent. For instance, the inflation coefficient of 1.79 for Sweden (forward-looking version) reflects that a one percent increase in inflation expectations is associated with an expected interest rate increase of about 1.8 percent. This in turn implies that the expected real interest rate increases by about .8 percent. The size of the inflation coefficient in the *ex-ante* Taylor rule is noticeably higher compared to studies estimating the *actual* Taylor rule. For example, estimating equation (4) with *actual* data for the time period 1993 to 2001, Neumann and von Hagen (2002) report an inflation coefficient of about 1.32 for Sweden.

Unlike in the cases of Denmark, Sweden and Switzerland, our results do not confirm the *Taylor principle* for Norway. In the short-term and forward-looking version, the inflation coefficient is not even different from zero indicating that the Bank of Norway is not expected to respond to an increase in expected inflation. Interestingly, for all countries considered, the inflation coefficient is the highest in the forward looking version. This indicates that professional forecasters expect the highest interest rate response to inflation assuming a nine months time lag for the monetary policy.

Third, the output gap coefficient (α_2) is positive in at least one specification in the case of Norway, Sweden, and Switzerland. This implies that professional forecasters tend to expect an interest rate increase if the output gap is expected to increase. The size of the output gap coefficient is comparable to studies focusing on the *actual* Taylor rule. Neumann and von Hagen (2002), for instance, estimate an inflation coefficient of about .03 for Swe-

den. Compared to the panel econometric results, the output gap coefficient is insignificant for Denmark suggesting that professional forecasters do not expect the Danmarks Nationalbank to respond to output developments.

In sum, Table 2 provides strong evidence that professional forecasts integrate the *Taylor principle* for Denmark, Sweden and Switzerland, while for Norway this is not the case as the interest rate response to inflation is considerably lower or does not even come out as significantly different from zero. This result is intuitive considering the different monetary policy regimes. While the inflation targeting countries (Sweden and Switzerland) are expected to actively fight inflation, this does not apply to Norway. Since Norway was an official exchange rate targeter between 1986 and 2001, forecasters do not expect the Bank of Norway to primarily respond to national macroeconomic variables but to the exchange rate. Including an exchange rate argument in the Taylor-type rule as a control variable, however, does not make sense because the central bank is expected to react to exchange rate pressure rather than observed exchange rate changes.

– Insert Tables 2 about here –

The question remains why the inflation coefficient for Denmark is higher than unity although Denmark targets its exchange rate to the euro by following monetary policy of the European Central Bank. We argue that since the European Central Bank targets the inflation rate and can be characterized by following a Taylor-type rule (Fendel and Frenkel, 2006), the inflation coefficient of Danmarks Nationalbank should also reflect this feature.

5 The (expected) long-term inflation rate

As already indicated, the estimation procedure allows us to investigate another feature inherent in the Taylor rule, i.e., the expected long-term inflation rate ($E\pi^*$). We then compare the expected long-term inflation rate with the

actual inflation rate and the official inflation target which provides us with some policy implications regarding central bank credibility. We could also directly insert the officially announced inflation target in equation (4) by assuming that professional forecasters believe in the inflation target. However, this yields similar results as reported in Table 2. Instead, we are interested in the long-term inflation rate implied by the professional forecasts. In order to recover the expected long-term inflation rate, we use the parameter estimates α_0 and α_1 from Table 2 reporting the estimates of equation (4). Recall that

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

Given the Fisher relationship

$$\bar{i} = i^{real} + E(\pi^*) \quad (7)$$

equation (5) can be written as

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

This implies that

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

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 long-term inflation rate $E(\pi^*)$ by means of the medium-term results shown in Table 2.¹⁶

¹⁶We 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. Note also that we assume that the expected long-term inflation rate is constant over time which is intuitive since the official inflation targets are not changed over the sample period.

Table 3 shows that for all countries considered the actual inflation rate is close to the expected long-term inflation rate over the sample period. For instance, the expected long-term inflation rate for Norway (Switzerland) is 2.62 (1.15) which is very close to the actual inflation target of 2.12 (.99). Additionally, Table 3 reports the values of a t -test comparing expected and actual inflation rates indicating that for all countries both values are not statistically different. Interestingly, the long-term inflation targets are consistent with the official inflation target for the three inflation targeting central banks. This points towards a high degree of credibility for these central banks.

– Insert Tables 3 about here –

6 Summary and Conclusions

This paper investigates whether professional forecasters believe in and, thus, apply Taylor-type rules in their forecasts for Denmark Norway, Sweden and Switzerland for the sample period between 1989 and 2008. While the literature has so far focused on revised or real-time data, our approach takes ex-ante data into consideration. To this end, 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 Denmark, Sweden and Switzerland. In the case of Norway, the *Taylor principle* is violated suggesting that professional forecasters do not expect the Bank of Norway to stabilize inflation directly. We argue that a rationale for this result is that Norway is a traditional exchange rate targeting country, while Sweden and Switzerland traditionally target the inflation rate. We believe that an important conclusion of our result is that the expectation formation process strongly depends on the monetary policy regime. We also find that the financial market expects a long-term inflation target which is comparable to both the actual average inflation rate and the inflation target. We take this

feature as evidence of a high degree of credibility of the respective central bank policy.

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

Country Data since	Norway 6/1998	Sweden 1/1995	Switzerland 6/1998	Denmark 10/1989
<hr/> <hr/> Interest Rate Forecasts				
Short-term	5.02	4.15	1.74	5.70
(Panel) unit root test	(2.42)	(2.58)	(3.28)	(-3.00)
Medium-term	5.06	4.51	2.09	5.53
(Panel) unit root test	(2.81)	(2.75)	(3.10)	(-3.38)
Actual Interest Rate	5.08	4.13	1.67	5.54
<hr/> <hr/> Source IMF				
<hr/> <hr/> CPI Forecasts				
Short-term	2.12	1.68	1.03	2.29
(Panel) unit root test	(3.41)	(2.19)	(2.72)	(-4.06)
Medium-term	2.15	2.02	1.19	2.42
(Panel) unit root test	(3.08)	(2.37)	(2.53)	(-4.09)
Actual CPI Growth	2.12	1.36	.99	2.24
<hr/> <hr/> Source IMF				
<hr/> <hr/> Real GDP				
Growth Forecast				
Short-term	2.37	2.58	1.72	1.99
(Panel) unit root test	(2.43)	(3.42)	(2.10)	(-17.46)
Medium-term	2.19	2.64	1.82	2.23
(Panel) unit root test	(2.19)	(3.64)	(2.71)	(-11.63)
Actual Growth Rate	2.25	2.60	1.86	1.86
<hr/> <hr/> Source IMF				

Notes: Table 1 shows the expected and the actual mean of the variables over the sample period October 1989/January 1995/June 1998 – December 2008; for Norway, Sweden and Switzerland the values in parentheses reflect t-values of the Pedroni panel unit root test under the null hypothesis of a unit root (Pedroni, 1999, 2004) while for Denmark the values in parentheses reflect the test statistic of the augmented dickey fuller test under the null of a unit root (Said and Dickey, 1984).

Table 2: 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
Norway (panel)	Short	3.80* (.51)	.35 (.28)	.09+ (.05)	.92* (.01)	.68* (.03)	.98	.03	.97	804	17
	Medium	4.81* (.31)	.29* (.12)	.01 (.01)	.54* (.03)	.88* (.03)	.98	.48	.76	749	17
	Forward	3.01* (.52)	.54 (.44)	.11* (.05)	.92* (.02)	.68* (.02)	.85	.01	.97	752	17
Sweden (panel)	Short	2.41* (.45)	1.16* (.19)	.05 (.04)	.93* (.01)	.71* (.01)	.21	.12	.97	1,931	29
	Medium	3.75* (.30)	1.29* (.13)	-.00 (.02)	.76* (.02)	.80* (.02)	.01	.58	.90	1,761	29
	Forward	1.24* (.13)	1.79* (.20)	.05+ (.03)	.91* (.01)	.68* (.01)	.00	.04	.97	1,774	29
Switzerland (panel)	Short	1.23* (.18)	.93* (.15)	.02 (.02)	.85* (.02)	.65* (.02)	.63	.17	.95	1,090	16
	Medium	1.97* (.13)	.87* (.13)	.02* (.01)	.60* (.03)	.81* (.03)	.68	.01	.84	976	16
	Forward	.60* (.11)	1.61* (.25)	-.01 (.02)	.86* (.02)	.64* (.02)	.00	.51	.95	964	16
Denmark (time-series)	Short	1.33 (.83)	2.03* (.31)	-.02 (.02)	.61* (.02)	–	.00	.95	–	226	–
	Medium	-.75 (.53)	2.70* (.20)	.01 (.01)	.33* (.01)	–	.00	.47	–	217	–
	Forward	-.76 (1.02)	2.96* (.42)	.01 (.03)	.64* (.01)	–	.00	.49	–	217	–

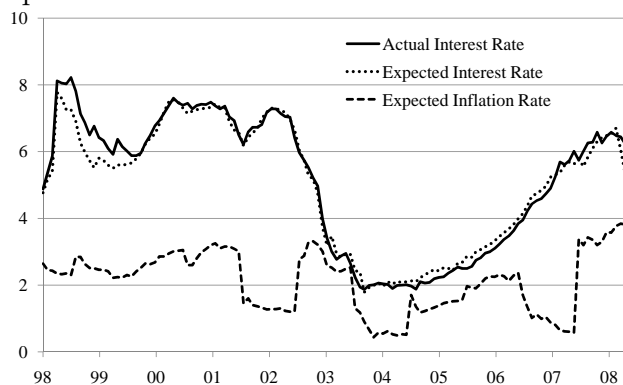
Notes: Estimated equation (4) $E_t i_{t+q,j} = (1-\rho)\alpha_0 + (1-\rho)\alpha_1 E_t \pi_{t+k,j} + (1-\rho)\alpha_2 E_t (\tilde{y}_{t+k,j}) + \rho i_t + \epsilon_{t,j}$ by the means of a serial correlation model (for Denmark with a ARIMA (0,0,3) model) where $\epsilon_{t,j} = \beta_j \epsilon_{t-1,j}$; values in parentheses present panel corrected standard errors applying the Prais-Winsten model; according to the Hausman test we either use the fixed-effects or random-effects estimator; $\alpha_1 > 1$ ($\alpha_2 > 0$) is a Chi^2 test on the null hypothesis that $\alpha_1 \leq 1$ ($\alpha_2 \leq 0$); the R^2 refers to the overall coefficient of determination; within and between R^2 are skipped from Table 2 for readability but available upon request; * (+) indicates significance at the one (ten) percent level, respectively.

Table 3: Expected Long-Term Inflation Target Rates and Actual Inflation Rates

Country	Norway	Sweden	Switzerland	Denmark
Inflation Targeting since	2001	1993	1999	–
Inflation Targeting	2.5	2	2	–
Exchange Rate Target since	1986	–	–	1999
Average Expected Real Interest Rate ($\bar{E}(i^{real})$)	2.96	4.09	1.61	3.11
Expected Inflation Target Rate ($E(\pi^*)$)	2.62 (.55)	1.19 (1.26)	1.15 (1.46)	2.28 (.09)
Actual Inflation Rate (π^{act})	2.12	1.36	.99	2.24
Test: $\pi^* = \pi^{act}$.37	.89	.91	.68

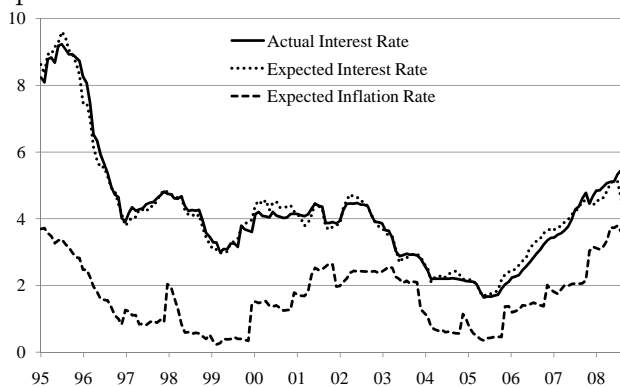
Notes: The expected real interest rate is the average of the real interest rate forecast over the sample period 1989/1995/1998 – 2008; the expected inflation rate is calculated by the means of (9) $E(\pi^*) = \frac{\alpha_0 - i^{real}}{1 - \alpha_1}$ based on the estimation results of Table 2 (medium-term specification); 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.

Figure 1: Expected and Actual Interest and Inflation Rate for Norway



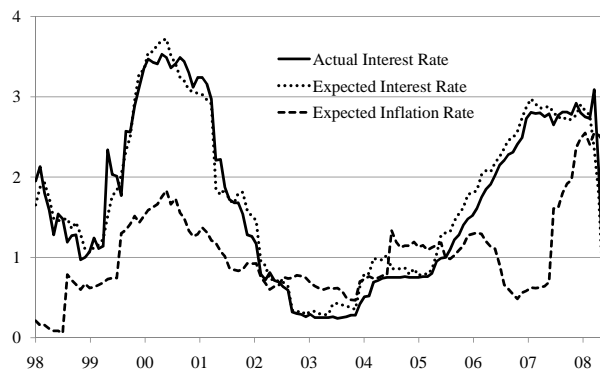
Notes: The solid (fine dotted) line represents the actual (expected) interest rate, while the dotted line reflects the expected inflation rate as of the time of the forecast.

Figure 2: Expected and Actual Interest and Inflation Rate for Sweden



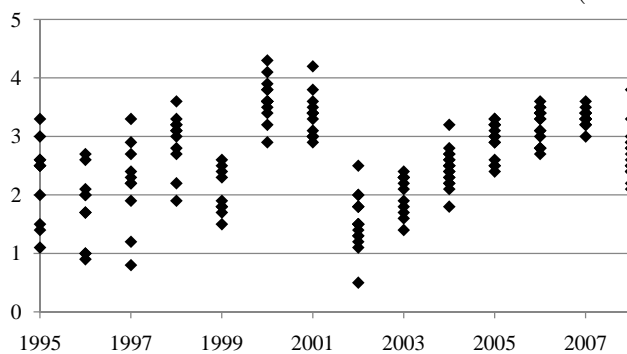
Notes: The solid (fine dotted) line represents the actual (expected) interest rate, while the dotted line reflects the expected inflation rate as of the time of the forecast.

Figure 3: Expected and Actual Interest and Inflation Rate for Switzerland



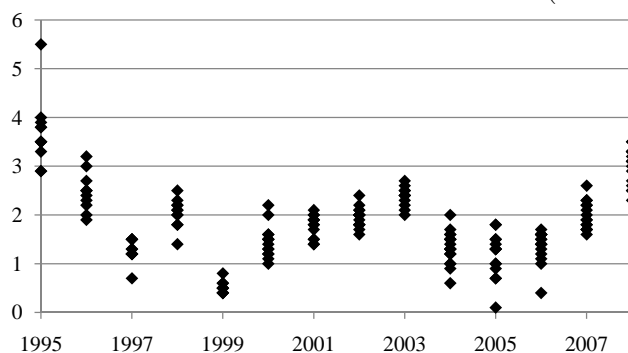
Notes: The solid (fine dotted) line represents the actual (expected) interest rate, while the dotted line reflects the expected inflation rate as of the time of the forecast.

Figure 4: Individual GDP Growth Forecasts for Sweden (January Forecasts)



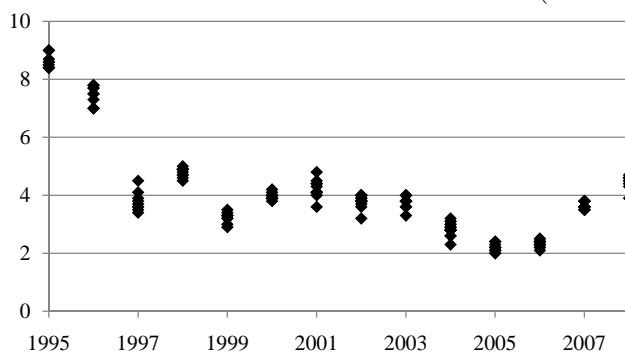
Notes: The points reflect individual GDP growth forecasts for Sweden which are published in January of the respective year.

Figure 5: Individual Inflation Forecasts for Sweden (January Forecasts)



Notes: The points reflect individual CPI growth forecasts for Sweden which are published in January of the respective year.

Figure 6: Individual Interest Forecasts for Sweden (January Forecasts)



Notes: The points reflect individual interest rate forecasts for Sweden which are published in January of the respective year.

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

In order to generate a three-month forecast we set the forecasted variable f_t at time t ($= 1, 2, \dots, 231$) 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 :

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

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

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

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