CHAPTER 9

# ASYMMETRIC MONETARY POLICY IN THE CZECH REPUBLIC?

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## 1. INTRODUCTION

One of the reasons for undershooting inflation targets may be in the application of the asymmetric monetary policy. The central banks, which perform inflation targeting, usually define *de iure* their inflation targets in a symmetric manner, i.e., the intensity of the monetary policy response is independent of whether the deviation of inflation from the target has been positive or negative. Nevertheless, there are several reasons why the monetary policy may be *de facto* asymmetric. For example, after the introduction of the inflation targeting regime, particularly under higher initial inflation rate (i.e., the case faced by the CNB), the central banks may justifiably fear difficulties with the anchoring of inflation expectations (risk of a credibility loss), which may lead them to apply asymmetric handling of inflation targets. Such asymmetry would in practice mean that the central banks would "increase their rates more if their inflation forecasts were 1 percentage point above the target, rather than reducing them if the inflation forecasts were 1 percentage point below the target".[1]

Asymmetric monetary policy is typically quantified by an estimation of the monetary policy rule (see e.g., Cukierman and Muscatelli (2008), Petersen (2007) or Taylor and Davradakis (2006)), i.e. by a test of whether the rule differs in relation to whether such inflation forecasts were above or under inflation targets (i.e., a test of the existence of so-called non-linear monetary policy rule). This paper estimates the CNB monetary policy rule, making use of the data relating to 1998Q1–2007Q3, and it provides an quantitative analysis of whether the monetary policy *ceteris paribus* responded with more aggressively with interest rates if the model inflation forecasts exceeded the target (i.e., there was the risk of non-anchoring of inflation expectations) that when the inflation forecasts were under the inflation target.[2]

The estimates of the monetary policy rule indicate that – following the introduction of inflation targeting – the CNB responded in a more aggressive manner to forecasts of inflation above the target. Such asymmetry, however, is not visible if the estimates of the monetary policy rule are carried only with the application of more contemporary data (approx. 2002–2007). Therefore, it can be claimed that currently symmetric handling of inflation targets prevails.

As shown by estimates of monetary policy rules performed by other central banks, asymmetric monetary policy does not seem to be so exceptional. Quantitative evidence on this topic show that, e.g., the monetary policy applied by Fed in the Grenspan era was asymmetric in that the Fed would apply a more aggressive response to inflation development if the inflation rate should exceed a certain threshold. A similar asymmetry has been identified also in the behaviour of the Bank of England in the 1990's, which responded in a more intense manner to the development of inflation, as long as its forecast was significantly higher than the inflation target.[3]

The paper is structured as follows. Section 2 describes the econometric model, data, and related literature. Section 3 presents the estimates of the monetary policy rule. The conclusion follows, as well as an annex containing a derivation of the monetary policy rule.

[1] Alternatively, it would be possible to assess whether a central bank responds faster or with a higher probability.
[2] We also make an assessment of whether the monetary policy responded in an asymmetric manner to interest rate forecasts.
[3] See e.g., Petersen (2007) for the Federal Reserve Bank, and Taylor and Davradakis (2006) for the Bank of England.





## 2. DATA DESCRIPTION AND MODEL

We use data from 1998Q1 to 2007Q3 (i.e., 39 observations) for the following variables: inflation forecasts and interest rates, model inflation target derived form QPM[4], the CZK/EUR exchange rate, the output gap, 3M PRIBOR and 1Y Euribor. In the period of 2002Q2–2007Q3, inflation forecasts come from the baseline QPM scenarios, while forecasts relating to the period of 1998Q1–2002Q1 come from estimates presented in the then current CNB Situation Reports, which are available on the CNB web site (see http://www.cnb.cz/cs/menova_politika/br_zapisy_z_jednani). The other data have been drawn from the baseline QPM scenarios (an internal CNB database).

Non-linearity of the monetary policy rules is tested as follows:

$$i_t = (1-\rho)[\alpha + \beta_1 \pi_{above} + \beta_2 \pi_{below} + \gamma X_t] + \rho i_{t-1} + \varepsilon_t \qquad (1)$$

where $\pi_{above}$ is defined as: $\pi_{above} = \pi^f_{t/t+4} - \pi^*_t$, if $\pi^f_{t/t+i} > \pi^*_t$, otherwise $\pi_{above} = 0$. Inflation forecasts in time $t$ for 4 quarters ahead (the choice of such horizon reflect the CNB monetary policy horizon for 4–6 quarters and data availability) is marked as $\pi^f_{t/t+4}$ and $\pi^*_t$ denotes the QPM model inflation target. Similarly, $\pi_{below}$ is defined as follows: $\pi_{below} = -(\pi^f_{t/t+i} - \pi^*_t)$, if $\pi^f_{t/t+i} < \pi^*_t$, otherwise $\pi_{below} = 0$. Deducting $\pi_{above} - \pi_{below}$, we get a time series of the differences of inflation forecasts from the target ($\pi^f_{t/t+4} - \pi^*_t$). Thus, it is a simple decomposition of the difference of the inflation forecasts from the target into two parts: inflation forecasts above the target ($\pi_{above}$) and inflation forecasts under the target ($\pi_{below}$). These two variables are shown in Figure 1.

$X_i$ represents all other variables (the exchange rate, output gap, and foreign interest rates, i.e., those variables, which have been most often incorporated in estimates of the monetary policy rules in the empirical literature), $i_t$ denotes 3M PRIBOR, $\alpha$ can be interpreted in certain specifications of monetary policy rules as a policy neutral rate, and $\varepsilon_t$ represents a residuum.[5] If neither the exchange rate nor foreign rates are included in vector $X$ in Equation 1 (thus, only the output gap, or no variable at all is inserted), this coefficient can be interpreted as a policy neutral rate. If the central bank conducts monetary policy in an asymmetric manner, Equation (1) implies that $\beta_1 \neq \beta_2$. More formal derivation of the monetary policy rule can be found in an annex to this paper.

We are aware of the issues related to changes from conditional forecasts to unconditional forecasts in 2002, when – in the latter case – long-term inflation always is directed to the target thanks to the built-in response of the monetary policy. Contrary to unconditional forecasts, conditional forecasts do not contain any monetary policy response and it is presumed that the interest rates are fixed at

[4] QPM – Quarterly Projection Model – is the main forecasting model applied by the CNB, made use of since 2002Q2. For a detailed description of the model see Coats *et al.* (2003).
[5] The current empiric records of estimates of monetary policy rules for the Czech Republic can be identified in the following papers: Horváth (2008) and Podpiera (2008). The issue of no-linear monetary policy rules is discussed in detail in Cukierman and Muscatelli (2008).

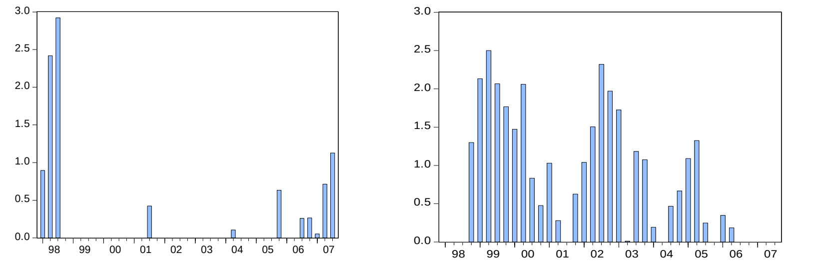
the current level. That indicates the possibility of a major difference between inflation forecasts and inflation targets along the monetary policy horizons. Still, even following the change to unconditional forecasts, Figure 1 shows that inflation forecasts in the horizon of 4 quarters differ from inflation targets, which is caused to a certain extent by the application of the institute of exemptions (they are mainly shocks on the supply side). This is why the paper further presents two sensitivity analyses, where – one – we apply forecast horizon 1Q instead of forecast horizon 4Q, which has not been affected by the change from conditional forecasts to unconditional forecasts, and – two – we estimate the reaction function with forecast interest rates. Yet another argument in support of such sensitivity analyses may be that the public did not distinguish enough between conditional and unconditional forecasts, and that inflation forecasts at the more distant forecast horizons might have been especially uncertain at the beginning of inflation targeting in the course of transition of the Czech economy.

In view of the fact that forecasts performed in transitional economies may be more uncertain than in more stable macroeconomic environments, it also would be of interest to note here exactly what role has been played by uncertainty in monetary policy decisions. Brainard (1967) claims that higher uncertainty in forecasting would rather support cautious monetary policy characterised by a greater degree of interest rate smoothing. On the other hand, Srour (1999) presents a model, which shows that in case of several uncertain parameters in the forecasting apparatus it is difficult to say whether a monetary policy response should be more aggressive or more cautious. For more details about relationships between uncertainty and monetary policy, please, see Šmídková (2003).

**Figure 1: Inflation forecasts above target ( $\pi_{above}$ ) and under target ( $\pi_{below}$ )**

*$\pi_{above}$ = forecast – target, if forecast > target, otherwise 0.*

*$\pi_{below}$ = – (forecast - target), if forecast < target, otherwise 0.*




*Notes: $\pi_{above}$ shows by how many percentage points inflation forecasts were above the targets in the given quarter (e.g., the left part of the figures shows that the 1998 inflation forecast was approx. 1–3 percentage point above the target). If forecasts were not above the target then the value of $\pi_{above}$ equals zero. Similarly, $\pi_{below}$ shows by how many percentage points the forecasts were below the targets (e.g., in 1999, it is obvious that the forecast was approx. 1.5–2.5 percentage point below the target). If forecasts were not below the target lower then the value of $\pi_{below}$ equal zero. All in all, Figure 1 shows that inflation forecasts for 4 quarters ahead were more often below the (model) inflation target.*





Other authors in this stream of literature estimate similar rules and model the Taylor Rule as asymmetric, either in inflation (e.g., Dolado et al., 2004, Bec et al., 2002), or in output, or in both of the varaibles at the same time, (e.g., Surico, 2007, Boinet and Martin, 2008). Some other authors capture asymmetry by adding, e.g., squared variables (e.g., Dolado et al. 2004), or they assume that the coefficients may differ within the monetary policy rules, depending on some threshold values, e.g., whether the economic growth was positive or negative, (Surico, 2007, Boinet and Martin, 2008, Bec et al. 2002).

Probably the most similar methodology as applied in this paper can be found in Davradakis and Taylor (2006), Bec et al. (2006), and Gredig (2007). It can be pointed out that the empirical methodology contained in this paper represents a special case of Davradakis and Taylor (2006). Davradakis and Taylor (2006) model the Taylor Rule using three regimes. One, if inflation is close to the target, the interest rate is not changed. Two, if inflation is sufficiently above the target, the central bank increases the rates. Three, if inflation is sufficiently below the target, the central bank reduces the rates. Contrary to Davradakis and Taylor (2006), our rule would not include the first regime (i.e., the changes would not occur if inflation is close to the target) and we take into consideration only the remaining two regimes. It is worth pointing out that Davradakis and Taylor (2006) apply data from the United Kingdom and their number of observations is three to six times higher, which in principle allows them to identify a higher number of regimes. Similarity between our methodology and that applied in Bec et al. (2002) is primarily based on the assumption of a known threshold value (Bec et al., 2006 assumes whether an economy was hit by recession or not, while our thresholds value (threshold) assumes whether inflation forecasts were above or under the target). Gredig (2007) estimates the asymmetric Taylor Rule, which to a large extent is identical with our methodology; the difference is in that our methodology would allow for an asymmetric response towards inflation, the Gredig model facilitates asymmetric response to inflation, the output gap, as well as to the interest rate smoothing (if asymmetric response to the output gap and the interest rate smoothing is not allowed, both models would be almost identical). Gredig (2007) estimates this rule in the case of Chile, based on monthly data relating to the years 1991–2007 (the disadvantage of this approach is, understandable, in the construction of the output gap on a monthly basis although the GDP data are available only on a quarterly basis).

Equation (1) has been estimated by the least squares. The least squares approach can be generally applied if the explanatory variables are not endogenous. In the opposite case, the parameters based on the least squares estimation would not be consistent. The least squares then can be applied to the Taylor rules if the value of the explanatory variables have been known before the monetary policy meeting (i.e., inflation forecasts and output gap in real time, lagged interest rates) or if the explanatory variables are exogenous (foreign interest rates for a small open economy), see Orphanides (2001). The output gap variable, unfortunately, is not available in real time (its regular reporting did not begin until mid-2002, following the introduction of the QPM), and therefore it may be endogenous, same as the exchange rates. Since the methods of instrumental variables is known that it can exhibit large small sample bias (see e.g., Ramalho, 2005), we lagged the output gap and the exchange rate by one period.

An alternative manner of evaluation of the asymmetric monetary policy may also be represented by an analysis of responses of monetary policy to interest rate forecasts and how those responses differ when such interest rate forecasts have headed higher or lower than the previous forecasts (i.e., whether the impact of reassessment of interest rate forecasts has been symmetrical). This is why we estimate Equation (2), which tests whether the monetary policy responses depend on the direction of reassessment of the level of interest rates (towards higher or lower rates):

$$i_t = \alpha_0 + \alpha_1 i_{t-1} + \beta_1 i_{above} + \beta_2 i_{below} + \varepsilon_t \quad (2)$$

where $i_t$ denotes 3M PRIBOR, $i_{above}$ is defined as: $i_{above} = i^f_{t/t+i}$, if $i^f_{t/t+i} > i^f_{t-1/t+i-1}$, otherwise $i_{above} = 0$. The interest rate forecasts in time *t* for *i* quarters ahead is denoted as $i^f_{t/t+i}$ (in this analysis, *i* equals either 1Q or 4Q). Similarly, $i_{below}$ is defined as follows: $i_{below} = i^f_{t/t+i}$, if $i^f_{t/t+i} < i^f_{t-1/t+i-1}$, otherwise $i_{below} = 0$. Thus, this is a simple decomposition of the interest rate forecasts into two parts, which reflect the direction of reassessment of the interest rates. A sum of $i_{above} + i_{below}$ gives back the time series of the forecasts of rates, $i^f_{t/t+i}$. Equation (2) has been estimated by the least squares because all explanatory variables are known prior to monetary policy meeting.

## 3. RESULTS

The results of the estimates of the monetary policy rule are reported in Table 1. The coefficient of variable $\pi_{above}$ is larger in all four specifications than the coefficient of variable $\pi_{above}$, and – with the exception of one single specification – we reject the zero hypothesis of equality of the coefficients ($\beta_1 = \beta_2$) of those variables. Therefore, the results indicate that the responses to the monetary policy were more aggressive if inflation forecasts were heading above the target than when the forecasts were heading under the target.

The sensitivity of results is assessed by the inclusion of other explanatory variables (the exchange rate, output gap, and foreign rates). We find that the output gap is not significant. According to the results in column (3), the appreciation of the exchange rate has been associated with lower interest rate. Similarly, lower foreign interest rate contributes lower domestic interest rate. Of course, it is not possible to interpret the statistical significance of the two last mentioned variables as if the CNB monetary policy responded directly to the development of the exchange rates and foreign interest rate, it rather means that those variables affect in significant manner inflation forecasts, which enter the reaction function of the CNB. A policy neutral rate (coefficient $\alpha$ in columns 1 and 2) usually fluctuates around 3%, which is the value that approximately complies with the QPM values as well as the estimates contained in Horváth (2008). The estimated degree of interest rate smoothing in the amount between 0.5–0.8 has been slightly higher that the QPM and the estimates contained in Horváth (2008), which estimate the smoothing parameter around 0.4.





**Table 1: Estimates of the non-linear monetary policy rule, 1998–2007**

Do the CNB interest rates respond more if the inflation forecasts are above target than if they are below target (i.e., is the coefficient of $\pi_{above}$ higher than the coefficient of $\pi_{below}$ ?)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| 3M PRIBOR (t-1) | $0.50^{*}$ | $0.80^{***}$ | $0.71^{***}$ | 0.46 |
| | [0.27] | [0.05] | [0.30] | [0.30] |
| $\alpha$ | $3.28^{***}$ | $2.99^{***}$ | $-22.7^{***}$ | -0.21 |
| | [0.89] | [0.69] | [4.95] | [1.19] |
| $\pi_{above}$ | $4.69^{***}$ | $2.58^{***}$ | $2.41^{***}$ | $4.35^{***}$ |
| | [0.84] | [0.57] | [0.38] | [0.71] |
| $\pi_{below}$ | 0.47 | $1.13^{*}$ | $0.82^{**}$ | 0.61 |
| | [0.73] | [0.92] | [0.633] | [0.68] |
| Output gap (t-1) | | -0.22 | | |
| | | [0.25] | | |
| Exchange rate (t-1) | | | $0.51^{***}$ | |
| | | | [0.07] | |
| 1Y EURIBOR | | | | $1.02^{**}$ |
| | | | | [0.40] |
| $\beta_1 = \beta_2$ [F-statistics] | $33.3^{***}$ | 1.78 | $7.02^{**}$ | $41.8^{***}$ |
| [p-value] | [0.00] | [0.18] | [0.00] | [0.00] |
| No. of observations | 39 | 39 | 39 | 39 |
| Adj. $R^2$ | 0.60 | 0.66 | 0.97 | 0.61 |

*Notes: Standard errors robust to autocorrelation and heteroskedasticity shown in brackets below the estimated parameters. *, **, *** denotes significance at 10, 5 and 1 level. The lower part of the table presents of the result of the test of the null hypothesis $\beta_1 = \beta_2$, i.e., whether the monetary policy has been symmetric.*

As an additional sensitivity analysis we present in Table 2 the estimates of the rule with inflation forecasts for 1 quarter ahead (instead of 4 quarters). Our conclusions relating to asymmetry of monetary policy does not seem to be affected by the change of the forecasting horizon. Carrying out such sensitivity analysis is relevant in particular due to the change from conditional forecasts to unconditional forecasts in 2002. It can be presumed that the resulting inflation forecasts for 1 quarter would be affected by such change to a substantially lesser extent that forecasts for 4 quarters (short-term forecasts do not have a built-in monetary policy response, which would have contributed to the return of the inflation back to target). Moreover, if we compare adj. $R^2$ for the rule with 4Q forecasts vs. 1Q forecasts (see Tables 1 and 2), we can see that adj. $R^2$ has been higher for the rule with 1Q. Therefore, the rule with forecasts for 1Q seem to represent a legitimate sensitivity analysis.

**Table 2: Estimates of non-linear monetary policy rule, 1998–2007, sensitivity analysis (forecast horizon 1Q instead of 4Q)**

*Do the CNB rates respond more if inflation forecasts are above target than if they are below target (i.e., is the coefficient of $\pi_{above}$ higher that the coefficient of $\pi_{below}$ ?)*

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| 3M PRIBOR (t-1) | 0.34* | 0.75*** | 0.66*** | 0.29 |
| | [0.21] | [0.06] | [0.06] | [0.21] |
| $\alpha$ | 3.12*** | 3.19*** | -8.05** | -0.54 |
| | [0.55] | [0.51] | [3.46] | [0.70] |
| $\pi_{above}$ | 3.37*** | 2.00*** | 1.72*** | 3.20*** |
| | [0.56] | [0.26] | [0.13] | [0.50] |
| $\pi_{below}$ | 0.24 | 0.26 | 0.32** | 0.41 |
| | [0.33] | [0.44] | [0.12] | [0.27] |
| Output gap (t-1) | | -0.03 | | |
| | | [0.17] | | |
| Exchange rate (t-1) | | | 0.36*** | |
| | | | [0.11] | |
| 1Y EURIBOR | | | | 1.02*** |
| | | | | [0.19] |
| $\beta_1 = \beta_2$ [F-statistics] | 30.5*** | 14.1*** | 43.5*** | 38.2*** |
| [p-value] | [0.00] | [0.00] | [0.00] | [0.00] |
| No. of observations | 39 | 39 | 39 | 39 |
| Adj. $R^2$ | 0.83 | 0.98 | 0.98 | 0.86 |

*Notes: Standard errors robust to autocorrelation and heteroskedasticity shown in brackets below the estimated parameters. *, **, *** denotes significance at 10, 5 and 1 level. The lower part of the table presents of the result of the test of the null hypothesis $\beta_1 = \beta_2$, i.e., whether the monetary policy has been symmetric.*

In this regard, another hypothesis comes up, namely, whether monetary policy asymmetry would change in time, i.e., the CNB might rather perceive the risk of unanchored inflation expectations as relevant after the introduction of inflationary conduct than at present. To evaluate any potential changes in asymmetry over time, we remove consecutively the first four observations in our sample (i.e., we perform so-called regression of the 1998–2007, 1999–2007, 2000–2007, 2001–2007, and 2002–2007 data)[6] and we also perform estimates using the data relating to the years 1998–2002. As far as this issue is concerned, we opt for an estimate of a very simple monetary policy rule (due to the low number of observations):

$$i_t = \alpha + \beta_1 \pi_{above} + \beta_2 \pi_{below} + \nu_t \qquad (2)$$

[6] Alternatively, recursive estimates of the parameters of the monetary policy rule have also been examined, nevertheless, standard errors in estimates were too large to assess any potential changes in asymmetry over time. The same applies also in the event of estimates of model with time-varying parameters.





This rule would thus assume that the central bank responds explicitly only to inflation. Although this rule may seem to be simplified at the first glance, we need to be aware that an absence of any other macroeconomic values needs not necessarily mean that they would be ignored. Those values enter into the rule at least indirectly because they affect the inflation forecasts (Taylor, 2001). An advantage of this rule, understandably, is a lower number of estimated parameters required; a disadvantage may be in a weaker relationship to the actual conduct of monetary policy (e.g., missing interest rate smoothing).[7]

The results of the estimates of such monetary policy rule from Equation (2) are presented in Table 3. Statistically significant asymmetry can only be noted in connection with the data from 1998–2007, if we ignore the first year of observations in the time series, the asymmetry cannot be identified any further. In order to assess the sensitivity of the results, we also estimate the given monetary policy rule in respect of the data from 1998–2002, which confirms that asymmetric monetary policy can be noted only in the period immediately after the introduction of inflation targeting. Similarly, the resulting values of $R^2$ show that asymmetry was present only in the initial years of inflation targeting. While $R^2$ has been relatively high for the estimates relating to the years 1998–2002 and 1998–2007, the $R^2$ value considerably decreases for any other specifications. That means that our non-linear/asymmetric monetary policy rule captures the behaviour of variables relatively well for the data belonging to the beginning of inflation targeting while afterwards the fit of the monetary policy rule worsens. In view of the low number of observations, uncertainty naturally prevails as regards the robustness of the results; still, it is possible to sum up that asymmetric handling of inflation targets has been relevant only at the beginning of the period following the introduction of inflation targeting (approx. 1998–2002).

The results in Table 3 also show estimates of a policy neutral rate (coefficient $\alpha$). That rate has fluctuated moderately under 3% if data relating to the years 1998–2007 were applied. If only the 1998–2002 data were applied, the results indicate higher rates, namely around 6.3%. This visible decline of a policy neutral rate in time complies with the estimates in the QPM and Horváth (2008), which apply different methods in the estimation of a policy neutral rate.

An estimate of Equation (2), which assesses potential asymmetric handling of the interest rate forecasts, is presented in Table 4. In order to facilitate the assessment of sensitivity of the results, we present our basic specifications of Equation (2), which differs in relation to whether we include lagged interest rate ($i_{t-1}$) and in relation to the forecast horizon of the interest rate forecast (1Q vs. 4Q). The results rather support the hypothesis of symmetric handling of the rates forecasts, even though two specifications indicate that it would be more important for the monetary policy in the interest rate forecasts were reassessed in direction to lower rates, rather than vice versa. Although the difference between the coefficients reflecting the effect of the direction of such re-assessment may be statistically significant (see equality test $\beta_1 = \beta_2$ in Table 1, columns 1 and 3), this seems to be marginal from the economic point of view. Moreover, if we also include the lagged interest rate, there is no different response identified even from the statistical point of view in respect of any reassessment of the rates. Therefore, the results suggest that monetary policy responses to the direction of reassessment of the interest rate forecasts are probably be symmetric, which supports our previous conclusions, namely, that the handling of inflation targets was symmetrical in the 2002–2007.

[7] Although a vivid debate exists in literature about the extent of the interest rate smoothing. Several authors (e.g., Rudebush, 2006) recently stressed that the extent of the interest rate smoothing has been low and many empirical approaches tend to overestimate its extent.

**Table 3: Estimates of the simplified monetary policy rule: Asymmetry in time?**

Do the CNB rates respond more if inflation forecasts are above target than if they are below target (i.e., is the coefficient of $\pi_{above}$ higher than the coefficient of $\pi_{below}$ ?)

| Period | 1998–2007 | 1999–2007 | 2000–2007 | 2001–2007 | 2002–2007 | 1998–2002 |
|---|---|---|---|---|---|---|
| $\alpha$ | 2.40*** | 2.54*** | 2.91*** | 2.77*** | 2.18*** | 6.33*** |
| | [0.76] | [0.64] | [0.64] | [0.50] | [0.13] | [1.67] |
| $\pi_{above}$ | 4.58*** | 0.75 | 0.21 | 0.42 | 0.77*** | 3.49*** |
| | [0.56] | [0.70] | [0.59] | [0.40] | [0.20] | [0.73] |
| $\pi_{below}$ | 1.48** | 1.19** | 0.43 | 0.18 | 0.39** | 0.38 |
| | [0.64] | [0.59] | [0.41] | [0.26] | [0.16] | [1.04] |
| $\beta_1 = \beta_2$ [F-statistics] | 11.6*** | 0.67 | 0.16 | 0.37 | 1.79 | 18.5*** |
| [p-value] | [0.00] | [0.41] | [0.69] | [0.55] | [0.19] | [0.00] |
| No. of observations | 39 | 35 | 31 | 27 | 23 | 20 |
| Adj. $R^2$ | 0.48 | 0.23 | 0.05 | 0.01 | 0.11 | 0.56 |

*Notes: Standard errors robust to autocorrelation and heteroskedasticity shown in brackets below the estimated parameters. *, **, *** denotes significance at 10, 5 and 1 level. The lower part of the table presents of the result of the test of the null hypothesis $\beta_1 = \beta_2$, i.e., whether the monetary policy has been symmetric.*

**Table 4: Asymmetric monetary policy depending on direction of reassessment of interest rate forecasts?, 2002–2007**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $i_t$ | | 0.18* | | 0.55*** |
| | | [0.10] | | [0.06] |
| $i_{above}$ | 0.94*** | 0.78*** | 0.39*** | 0.31*** |
| | [0.06] | [0.11] | [0.07] | [0.11] |
| $i_{below}$ | 1.01*** | 0.80*** | 0.49*** | 0.32*** |
| | [0.06] | [0.13] | [0.08] | [0.13] |
| $\beta_1 = \beta_2$ [F-statistics] | 5.51** | 0.65 | 4.88** | 0.21 |
| [p-value] | [0.03] | [0.43] | [0.04] | [0.65] |
| No. of observations | 21 | 21 | 21 | 21 |
| Adj. $R^2$ | 0.90 | 0.92 | 0.57 | 0.93 |

*Notes: Standard errors robust to autocorrelation and heteroskedasticity shown in brackets below the estimated parameters. *, **, *** denotes significance at 10, 5 and 1 level. The lower part of the table presents of the result of the test of the null hypothesis $\beta_1 = \beta_2$, i.e., whether the monetary policy has been symmetric. Columns (1) and (2) based on the interest rate forecasts for horizon 1Q, columns (3) and (4) for horizon 4Q.*





## 4. CONCLUSIONS

This paper deals with the topic of asymmetric handling of inflation targets by estimating of the monetary policy rule. The results indicate that, following the introduction of inflation targeting, the CNB responded in a more aggressive manner to inflation forecasts heading above the target. That asymmetry, however, is vanishing if we estimate the monetary policy rule only using the contemporary data (approx. 2002–2007). Therefore, inflation target handling has been deemed as symmetric over the several past years.

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## APPENDIX: DERIVATION OF THE MONETARY POLICY RULE [8]

The initial step in the formal derivation of the monetary policy rules is represented by an assumption that the central bank targets to set the nominal interest rate in line with the state of the economy , as in Equation (1):

$$i_t^* = \alpha + \beta\left(E\left\{\pi_{t+i}\middle|\Omega_t\right\} - \pi_{t+i}^*\right) + \gamma E\left\{x_t\middle|\Omega_t\right\} \qquad (3)$$

$i_t^*$ denotes the target interest rate, $\alpha$ is a policy neutral rate, $\pi_{t+i}$ represents a forecast of the year-on-year inflation rate of the central bank for *i* periods ahead, $\pi_{t+i}^*$ means the inflation target of the central bank, $x_t$ represents the output gap, $E(.)$ is the expectation operator, and $\Omega_t$ denotes the information set, which is available at the time of the monetary policy decision. This is why Equation (1) connects the target nominal interest rate and the constant (i.e., interest rate – policy neutral rate –, which occurs if the expected inflation hits the target and there is a zero output gap), the difference between the expected inflation and the inflation targets and the output gap.

Nevertheless, it is often claimed that Equation (3) has been too restrictive because it does not consider the interest rate smoothing. Clarida *et al.* (1998) assume that the central bank would adjust step by step its interest rates to the target value due to several reasons. For example, the central bank may worry about the financial stability in the event of any major changes of the interest rates, or uncertainty has often been underscored in relation to the impact of changes of interest rates on the real economy.

Instead of explicit incorporation of all potentially relevant factors of interest rates smoothing, Clarida *et al.* (1998) assume for the sake of simplicity that the actual monetary policy rate represent a combination of their lagged and target values, as shown by Equation (4).

$$i_t = \rho i_{t-1} + (1-\rho) i_t^* + \nu_t \qquad (4),$$

where $\rho \in [0,1]$. In line with Clarida *et al.* (1998), we would substitute Equation (4) to Equation (3) and eliminate unobservable forecast variables, and thus we arrive at Equation (5):

$$r_t = (1-\rho)\left[\alpha + \beta\left(\pi_{t+i} - \pi_{t+i}^*\right) + \gamma x_t\right] + \rho r_{t-1} + \varepsilon_t \qquad (5)$$

It is interesting to note that $\varepsilon_t$ denotes a combination of forecast errors, and that it thus is orthogonal towards all available information in time *t* ($\Omega_t$). Since Equation (5) has not been estimated by GMM but with the least squares method, we would keep inflation forecast instead of an actual future inflation. The standard form of the monetary policy rule, therefore, is as follows:

$$i_t = (1-\rho)\left[\alpha + \beta\left(\pi_{t+i}^f - \pi_{t+i}^*\right) + \gamma x_t\right] + \rho i_{t-1} + \varepsilon_t \qquad (6)$$

[8] For further information regarding monetary policy rules, please, see – e.g., Horváth (2008) and Podpiera (2008).

where $i_t$ denotes 3M PRIBOR, $\alpha$ is a politically neutral rate, $\pi^f_{t+i}$ represents year-on-year inflation rate forecast by the central bank for *i* period ahead, $\pi^*_{t+i}$ is the inflation target of the central bank, $x_t$ represents the output gap, and $\varepsilon_t$ denotes residuum. Let us denote $k = \left(\pi^f_{t+i} - \pi^*_{t+i}\right)$. We would define $\pi_{above}$ as: $\pi_{above} = \pi^f_{t/t+i} - \pi^*_t$, if $\pi^f_{t/t+i} > \pi^*_t$, otherwise $\pi_{above} = 0$ and $\pi_{below} = -(\pi^f_{t/t+i} - \pi^*_t)$, if $\pi^f_{t/t+i} < \pi^*_t$, otherwise $\pi_{below} = 0$. Then $k$ can be decomposed into two parts, $\pi_{above}$ and $\pi_{below}$, as follows: $k = \pi_{above} - \pi_{below}$. If the monetary policy is symmetric, it will be valid that $\beta k = \beta_1\pi_{above} + \beta_2\pi_{below}$ (i.e., $\beta_1 = \beta_2 = \beta$). A simple asymmetry test is then to examine whether $\beta_1 = \beta_2$.