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Asymmetric Monetary Policy in the Czech Republic?*

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Abstract
This paper analyses the hypothesis of whether asymmetric monetary policy could have contributed to the undershooting of the inflation targets of the Czech National Bank in the years 1998–2007. To this end, a non-linear Taylor Rule is estimated. The results indicate that from 1998 to about 2002, the Czech National Bank responded more aggressively to forecasts of inflation exceeding the target than to those below the target. There is, however, no evidence for asymmetric monetary policy in estimates of the monetary policy rule derived from more recent data. This suggests that symmetric handling of the inflation targets prevailed in the past several years.

1. Introduction

One of the reasons for undershooting inflation targets may be the application of an asymmetric monetary policy. Central banks that perform inflation targeting usually define *de jure* 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 is positive or negative. Nevertheless, there are several reasons why monetary policy may be *de facto* asymmetric. For example, after the introduction of inflation targeting, particularly under a higher initial inflation rate (i.e., the case faced by the CNB), central banks may justifiably fear difficulties with anchoring inflation expectations (the risk of a credibility loss), which may lead them to apply asymmetric handling of inflation targets. Such asymmetry would in practice mean that 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 estimating a 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 inflation forecasts were above or below the inflation targets (i.e., a test for the existence of a 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 provides a quantitative analysis of whether the CNB responded *ceteris paribus* more aggressively with interest rates if the model inflation forecasts exceeded

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[1] Alternatively, it would be possible to assess whether a central bank responds faster or with a higher probability.

the inflation target (i.e., there was a risk of non-anchoring of inflation expectations) than when the forecasts were under the 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 detected in the estimates of the monetary policy rule based only on more recent data (approximately 2002–2007). Therefore, it can be claimed that symmetric handling of inflation targets has prevailed in recent years.

As shown by the estimates of monetary policy rules performed by other central banks, asymmetric monetary policy does not seem to be so exceptional. Quantitative evidence shows that, for example, the monetary policy applied by Fed in the Greenspan era was asymmetric in that the Fed would apply a more aggressive response to inflation developments if the inflation rate exceeded a certain threshold (e.g., (Petersen, 2007)). A similar asymmetry has been identified also in the behavior of the Bank of England in the 1990s (Taylor and Davradakis, 2006).

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. Section 4 concludes. An annex contains the derivation of the monetary policy rule.

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, the CNB inflation target,[3] the CZK/ /EUR exchange rate, the output gap, the 3M PRIBOR, and the 1Y Euribor. In the period of 2002Q2–2007Q3, the inflation forecasts come from the baseline QPM scenarios, while the forecasts relating to 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 are taken from the baseline QPM scenarios (an internal CNB database).

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

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

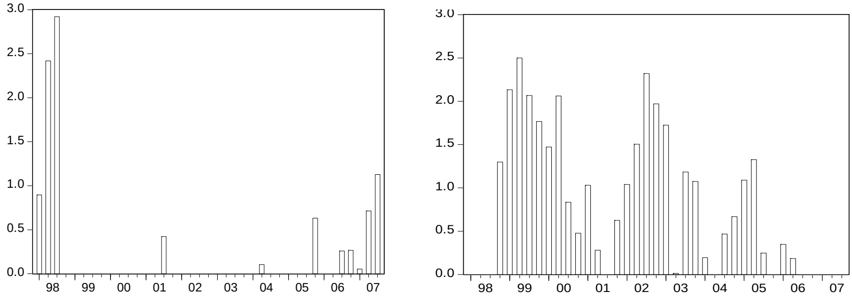
where π_{above} is defined as: $\pi_{above} = \pi^f_{t/t+4} - \pi^*_t$ if $\pi^f_{t/t+i} > \pi^*_t$, otherwise $\pi_{above} = 0$. The inflation forecast at time *t* for 4 quarters ahead (the choice of this horizon reflects the CNB monetary policy horizon of 4–6 quarters and the data availability) is marked as $\pi^f_{t/t+4}$ and π^*_t denotes the QPM model inflation target. Similarly, π_{below} is defined as follows:

$$\pi_{below} = -(\pi^f_{t/t+i} - \pi^*_t) \text{ if } \pi^f_{t/t+i} < \pi^*_t \text{, otherwise } \pi_{below} = 0$$

[2] We also make an assessment of whether monetary policy responded in an asymmetric manner to interest rate forecasts.

[3] For the period during which the target was published only as a band, the mean value of the range is considered, while for the period during which the target was set as net inflation, the relevant values are adopted from the CNB's main prediction model – the QPM. For a detailed description of the QPM, see (Coats et al., 2003).

FIGURE 1 – Inflation Forecasts above Target (π_{above}) and below Target (π_{below})



Notes: π_{above} shows by how many percentage points the inflation forecasts were above the targets in the given quarter (e.g., the left-hand part of the chart shows that the 1998 inflation forecast was approximately 1–3 pp above the target). If the forecasts were not above the target then π_{above} equals zero. Similarly, shows by how many percentage points the forecasts were below the targets (e.g., in 1999, it is obvious that the forecast was around 1.5–2.5 pp below the target). If the forecasts were not below the target, then π_{below} equals zero. All in all, Figure 1 shows that the inflation forecasts for 4 quarters ahead were more often below the (model) inflation target.

Deducting $\pi_{above} - \pi_{below}$, we get a time series of the differences of the inflation forecasts from the target ($\pi^f_{t/t+4} - \pi^*_t$). Thus, this is a simple decomposition of the difference of the inflation forecasts from the target into two parts: inflation forecasts above the target (π_{above}) and inflation forecasts below the target (π_{below}). These two variables are shown in *Figure 1*.

X_i represents all other variables (the exchange rate, the output gap, and foreign interest rates, i.e., those variables which have most often been incorporated into estimates of monetary policy rules in the empirical literature), i_t denotes the 3M PRIBOR, α can be interpreted in certain monetary policy rule specifications as a policy neutral rate, and ε_t represents a residuum.[4] 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 $\beta_1 \neq \beta_2$. A more formal derivation of the monetary policy rule can be found in the annex to this paper.

In 2002, the CNB switched from conditional forecasts to unconditional forecasts. In the latter case, long-term inflation is always directed to the target thanks to the built-in monetary policy response. Contrary to unconditional forecasts, conditional forecasts do not contain any monetary policy response and it is presumed that interest rates are fixed at the current level. That indicates the possibility of a major difference between inflation forecasts and inflation targets along the monetary policy

[4] For the current empirical record of estimates of monetary policy rules for the Czech Republic, see (Horváth, 2009) and (Podpiera, 2008). The issue of non-linear monetary policy rules is discussed in detail in (Cukierman and Muscatelli, 2008).

horizons. Still, even following the change to unconditional forecasts, *Figure 1* shows that the inflation forecasts at the horizon of 4 quarters differ from the inflation targets. This is due to some extent to the application of exemptions (these are mainly the supply side shocks). This is why the paper additionally presents two sensitivity analyses. In the first, instead of 4Q we apply a forecast horizon of 1Q, which is not affected by the change from conditional to unconditional forecasts. And in the second, we estimate the reaction function with forecast interest rates. Yet another argument in support of such sensitivity analyses is that the public did not distinguish enough between the conditional and unconditional forecasts and that the inflation forecasts at the more distant forecast horizons might have been especially uncertain at the beginning of inflation targeting in the Czech economic transition.

Given that the forecasts for transition economies may be more uncertain than those in more stable macroeconomic environments, it is important to acknowledge here the role played by uncertainty in monetary policy decisions. The literature is not completely unanimous on this topic. On the one hand, Brainard (1967) and a number of subsequent papers claim that higher uncertainty in forecasts calls for cautious monetary policy, characterized by a greater degree of interest rate smoothing. On the other hand, Srour (1999) presents a model showing that in the case of several uncertain parameters in the forecasting apparatus it is difficult to say whether the monetary policy response should be more aggressive or more cautious. For a more detailed discussion of the relationships between uncertainty and monetary policy, see (Šmídková, 2003).

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), and (Bec et al., 2002)), or in output, or in both of the variables at the same time, (e.g., (Surico, 2007), and (Boinet and Martin, 2008)). Some other authors capture asymmetry by adding, for example, 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, for example whether the economic growth was positive or negative (Surico, 2007), (Boinet and Martin, 2008), and (Bec et al., 2002).

Probably the most similar methodology to that applied in this paper can be found in (Davradakis and Taylor, 2006), (Bec et al., 2006), and (Gredig, 2007). The empirical methodology contained in this paper represents a special case of Davradakis and Taylor (2006), who 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 its rates. Three, if inflation is sufficiently below the target, the central bank reduces its rates. Contrary to Davradakis and Taylor (2006), the rule used in this paper 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. The 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) assume whether the economy was hit by recession or not, while our threshold assumes whether inflation forecasts were above or below the target). Gredig (2007) estimates the asymmetric Taylor Rule, which to a large extent is identical with our methodology; the difference is that our methodology would allow for an asymmetric response to inflation, whereas the Gredig model facilitates an asymmetric response to inflation, the output gap, and interest rate smoothing (if an asymmetric response to the output gap and interest rate smoothing was not allowed, the two 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, understandably, in the construction of the output gap on a monthly basis although the GDP data are available only on a quarterly basis).

Equation (1) was estimated by 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 approach can then be applied to the Taylor rules if the values of the explanatory variables were known before the monetary policy meeting (i.e., the 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 (regular reporting thereof did not begin until mid-2002, following the introduction of the QPM), and therefore it may be endogenous, the same as the exchange rates. Since it is known that the method of instrumental variables can exhibit large small sample bias (see, for example, (Ramalho, 2005)), we lagged the output gap and the exchange rate by one period.

An alternative approach to evaluating the symmetry of monetary policy is to analyze the responses of monetary policy to interest rate forecasts and how those responses differ when such interest rate forecasts were heading higher or lower than the previous forecasts (i.e., whether the impact of reassessing the interest rate forecasts is symmetric). 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 (toward higher or lower rates):

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

where i_t denotes the 3M PRIBOR, and i_{above} is defined as: $i_{above} = i^f_{t/t+i}$ if , otherwise $i_{above} = 0$. The interest rate forecast at 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 interest rates. The sum of $i_{above} + i_{below}$ returns the time series of the rate forecasts, $i^f_{t/t+i}$. Equation (2) was estimated by least squares because all the explanatory variables are known prior to the monetary policy meeting.

3. Results

The results of the estimates of the monetary policy rule are reported in *Table 1*. The coefficient of variable π_{above} is larger in all four specifications than the coefficient

TABLE 1 Estimates of the Non-linear Monetary Policy Rule, 1998–2007

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

	(1)	(2)	(3)	(4)
3M PRIBOR (*t*-1)	0.50* [0.27]	0.80*** [0.05]	0.71*** [0.30]	0.46 [0.30]
α	3.28*** [0.89]	2.99*** [0.69]	-22.7*** [4.95]	-0.21 [1.19]
π_{above}	4.69*** [0.84]	2.58*** [0.57]	2.41*** [0.38]	4.35*** [0.71]
π_{below}	0.47 [0.73]	1.13* [0.92]	0.82** [0.633]	0.61 [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] [*p*-value]	33.3*** [0.00]	1.78 [0.18]	7.02** [0.00]	41.8*** [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 are shown in brackets below the estimated parameters.
*, **, *** denote significance at the 10, 5, and 1 percent level, respectively.
The lower part of the table presents the result of the test of the null hypothesis $\beta_1 = \beta_2$, i.e., whether monetary policy was symmetric.

the coefficient of variable π_{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 monetary policy responses were more aggressive when the inflation forecasts were heading above the target than when the forecasts were heading below the target.

The sensitivity of the results is assessed by including other explanatory variables (the exchange rate, the output gap, and foreign interest rates). We find that the output gap is not significant. According to the results in column (3), appreciation of the exchange rate was associated with a lower interest rate. Similarly, lower foreign interest rates contribute to lowering the domestic interest rate. Of course, it is not possible to interpret the statistical significance of the two last-mentioned variables as if CNB monetary policy responded directly to the development of exchange rates and the foreign interest rate; it rather means that those variables significantly affect the inflation forecasts, which enter the reaction function of the CNB. The policy neutral rate (coefficient α in columns 1 and 2) usually fluctuates around 3 percent, which is approximately in line with the QPM values as well as the estimates contained in (Horváth, 2009). The estimated degree of interest rate smoothing (0.5–0.8) is slightly higher than the QPM and the esti-

TABLE 2 Estimates of Non-linear Monetary Policy Rule, 1998–2007, sensitivity analysis (forecast horizon 1Q instead of 4Q)

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

	(1)	(2)	(3)	(4)
3M PRIBOR (t-1)	0.34* [0.21]	0.75*** [0.06]	0.66*** [0.06]	0.29 [0.21]
α	3.12*** [0.55]	3.19*** [0.51]	-8.05** [3.46]	-0.54 [0.70]
π_{above}	3.37*** [0.56]	2.00*** [0.26]	1.72*** [0.13]	3.20*** [0.50]
π_{below}	0.24 [0.33]	0.26 [0.44]	0.32** [0.12]	0.41 [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] [*p*-value]	30.5*** [0.00]	14.1*** [0.00]	43.5*** [0.00]	38.2*** [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 are shown in brackets below the estimated parameters.
*, **, *** denote significance at the 10, 5, and 1 percent level, respectively.
The lower part of the table presents the result of the test of the null hypothesis $\beta_1 = \beta_2$, i.e., whether monetary policy was symmetric.

mates contained in (Horváth, 2009), which estimate the smoothing parameter at around 0.4.

As an additional sensitivity analysis, *Table 2* presents the estimates of the rule with inflation forecasts for one quarter ahead (instead of four quarters). The conclusions relating to the asymmetry of monetary policy do not seem to be affected by the change of forecasting horizon. Carrying out such a 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 this change to a substantially lesser extent than the forecasts for 4 quarters (short-term forecasts do not have a built-in monetary policy response, which would have contributed to the return of inflation to the 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 is higher for the rule with 1Q. Therefore, the rule with the forecasts for 1Q seems to represent a legitimate sensitivity analysis.

A related hypothesis is whether there was a change in monetary policy asymmetry over time. In particular, it is possible that the CNB perceived the risk of unanchored inflation expectations much more relevant after the introduction of inlation targeting than it did in later periods. To evaluate any changes in asymmetry

TABLE 3 Estimates of the Simplified Monetary Policy Rule: Asymmetry in Time?
Do the CNB's rates respond more if inflation forecasts are above target than if they are below target (i.e., is the coefficient of π_{above} higher than the coefficient of π_{below} ?)

Period	**1998––2007**	**1999––2007**	**2000––2007**	**2001––2007**	**2002––2007**	**1998––2002**
α	2.40*** [0.76]	2.54*** [0.64]	2.91*** [0.64]	2.77*** [0.50]	2.18*** [0.13]	6.33*** [1.67]
π_{above}	4.58*** [0.56]	0.75 [0.70]	0.21 [0.59]	0.42 [0.40]	0.77*** [0.20]	3.49*** [0.73]
π_{below}	1.48** [0.64]	1.19** [0.59]	0.43 [0.41]	0.18 [0.26]	0.39** [0.16]	0.38 [1.04]
$\beta_1 = \beta_2$ [F-statistics] [*p*-value]	11.6*** [0.00]	0.67 [0.41]	0.16 [0.69]	0.37 [0.55]	1.79 [0.19]	18.5*** [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 are shown in brackets below the estimated parameters.
*, **, *** denote significance at the 10, 5, and 1 percent level, respectively.
The lower part of the table presents the result of the test of the null hypothesis $\beta_1 = \beta_2$, i.e., whether monetary policy was symmetric.

over time, we remove consecutively the first four observations in our sample (i.e., we perform a so-called regression of the 1998–2007, 1999–2007, 2000–2007, 2001––2007, and 2002–2007 data)[5] and we also perform estimates using the data relating to the years 1998–2002. Due to the low number of observations, we opt for estimating a simple monetary policy rule:

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

This rule assumes that the central bank responds explicitly only to inflation. Although this rule may seem to be overly simplified at first glance, we need to be aware that the absence of other macroeconomic variables does not necessarily mean that they are ignored. Those values enter the rule at least indirectly because they affect the inflation forecasts (Taylor, 2001). An advantage of this rule is the 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).[6]

The results of the estimates of the 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

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

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

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 are shown in brackets below the estimated parameters.

*, **, *** denote significance at the 10, 5, and 1 percent level, respectively.

The lower part of the table presents the result of the test of the null hypothesis $\beta_1 = \beta_2$, i.e., whether monetary policy was symmetric.

Columns (1) and (2) are based on the interest rate forecasts for the 1Q horizon, and columns (3) and (4) for the 4Q horizon.

the time series, the asymmetry can no longer be identified. 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 R^2 values show that the asymmetry was present only in the initial years of inflation targeting. While R^2 is relatively high for the estimates relating to 1998–2002 and 1998–2007, it considerably decreases for any other specifications. This means that our non-linear/asymmetric monetary policy rule captures the behavior of the variables relatively well for the data pertaining 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 was relevant only at the beginning of the period following the introduction of inflation targeting (approximately 1998–2002).

The results in *Table 3* also show the estimates of the policy neutral rate (coefficient α). That rate fluctuates moderately under 3 percent if data relating to the years 1998–2007 are applied. If, and only if, the 1998–2002 data are applied, the results indicate higher rates, namely, around 6.3 percent. This visible decline in the policy neutral rate over time is consistent with the estimates in the QPM and Horváth (2009), which apply different methods to the estimation of the 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 the sensitivity of the results, we present our basic specifications of equation (2), which differs in relation to whether we include the lagged interest rate (i_{t-1}) and in relation to the forecast horizon of the interest rate forecast (1Q vs. 4Q). The results tend to support the hypothesis of symmetric handling of rate forecasts, even though two specifications indicate that it would be more important for monetary policy if the interest rate forecasts were reassessed toward lower rates rather than toward higher rates. Although the difference between the coefficients reflecting the effect of the direction of such reassessment may be statistically significant (see the 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, no different response is identified even from the statistical point of view in respect of any reassessment of rates. Therefore, the results suggest that the monetary policy responses to the direction of reassessment of the interest rate forecasts are probably symmetric, which supports our previous conclusion, namely, that the handling of inflation targets was symmetric in 2002–2007.

4. Conclusions

This paper tests whether inflation targets in the Czech Republic were treated symmetrically. 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, vanishes if we estimate the monetary policy rule only using contemporary data (approximately 2002–2007). Therefore, inflation target handling is deemed to have been symmetric over the past several years.

ANNEX

Derivation of the monetary policy rule[7]

The initial step in the formal derivation of the monetary policy rule is to assume that the central bank aims to set the nominal interest rate in line with the state of the economy, as in equation (1):

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

where i_t^* denotes the target interest rate, α is the policy neutral rate, π_{t+i} represents a forecast of the year-on-year inflation rate of the central bank for i periods ahead, π_{t+i}^* means the inflation target of the central bank, x_t represents the output gap, $E(.)$ is the expectation operator, and Ω_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., the interest rate – policy neutral rate – which occurs if expected inflation hits the target and there is a zero output gap), the difference between expected inflation and the inflation targets, and the output gap.

Equation (3) may be too restrictive because it does not consider interest rate smoothing. Clarida et al. (1998) assume that the central bank would adjust its interest rates step by step to the target value for several reasons. For example, the central bank may be worried about financial stability in the event of any major changes of

[7] For further information regarding monetary policy rules, see, e.g., (Horváth, 2009) and (Podpiera, 2008).

interest rates, and uncertainty has often been emphasized in relation to the impact of changes of interest rates on the real economy.

Instead of explicitly incorporating all potentially relevant factors of interest rate smoothing, Clarida et al. (1998) assume for the sake of simplicity that the actual monetary policy rate represents a combination of lagged and target values, as shown by equation (4).

$$i_t = \rho i_{t-1} + \left(1-\rho\right) i_t^* + \nu_t \tag{4}$$

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

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

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

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

where i_t denotes the 3M PRIBOR, α is the politically neutral rate, π_{t+i}^f represents the year-on-year inflation rate forecast of the central bank for *i* periods ahead, π_{t+i}^* is the inflation target of the central bank, x_t represents the output gap, and ε_t denotes the residuum. Let us denote $k = \left(\pi_{t+i}^f - \pi_{t+i}^*\right)$. We define π_{above} as: $\pi_{above} = \pi_{t/t+i}^f - \pi_t^*$ if $\pi_{t/t+i}^f > \pi_t^*$, otherwise $\pi_{above} = 0$, and $\pi_{below} = -(\pi_{t/t+i}^f - \pi_t^*)$ if $\pi_{t/t+i}^f < \pi_t^*$, otherwise $\pi_{below} = 0$. Then k can be decomposed into two parts, π_{above} and π_{below}, as follows: $k = \pi_{above} - \pi_{below}$. If monetary policy is symmetric, it will hold 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 $\beta_1 = \beta_2$.

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