

CHAPTER 10

**REASONS OF UNDERSHOOTING THE INFLATION TARGET IN THE CZECH  
REPUBLIC: THE ROLE OF INFLATION EXPECTATIONS**

ROMAN HORVÁTH

## 1. INTRODUCTION

The inflation targeting regime was introduced in the Czech Republic 10 years ago and there has been still a comparatively limited number of empirical studies explicitly attempting any evaluation as to whether and how such monetary policy regime has actually contributed to anchoring of the inflation expectations.<sup>1</sup> The key purpose of this article is to estimate an extent to which the CNB's inflation target and monetary policy have been impacting the inflation expectations, particularly in relation to frequent undershooting of the inflation target.

The “hypercredible” inflation target hypothesis, under which a 1 pp reduction would induce a decrease of inflation expectations by more than 1 pp in the long term, represents one of the inflation target undershooting options. Lower inflation expectations of economic subjects would then contribute to inflation stabilisation at the values below the inflation target. The inflation target, according to our econometric analysis, is a major determinant of inflation expectations, albeit nothing to support the “hypercredible” inflation target hypothesis has been found.<sup>2</sup> Relying on the 1999–2007 data, our estimates have indicated that the 1 pp reduction of the inflation target would be on average accompanied by a 0.4 pp drop of the financial market inflation expectations for the inflation expectations during the 12-month horizon, and, by a 0.6 pp drop for the inflation expectations over the 36-month horizon.

This article also addresses relationships between inflation expectations, the target and other macroeconomic variables over a short-time period, using the impulse response analysis and variance decomposition within the block restriction vector autoregression model.<sup>3</sup> We identify a statistically relevant decrease of inflation expectations in response to the stricter monetary policy and to the lower inflation target. The performed econometric analysis has on the overall indicated the credibility of the CNB's monetary policy. While the key determinant of inflation expectations is represented by the foodstuff prices in the short term, it is the inflation target that impacts the inflation expectations development in the longer term. On the overall, the results indicate that the CNB's monetary policy has anchored the inflation expectations.

The article is structured as follows: Section 2 contains a brief outline of the econometric model and data. Section 3 presents the results and Section 4 summarises the conclusions. An Appendix with additional results follows afterwards.

<sup>1</sup> The empirical literature typically analyzes the inflation target impact on other macroeconomic quantities (such as: development of – expected – inflation and GDP) or their characteristics (such as volatility or persistence of inflation). Mishkin and Schmidt-Hebbel (2006), for example, have analysed an impact of inflation targeting on the level of inflation, as well as intensity of inflation response to various shocks. Levin *et al.* (2004), Vega and Winkelried (2005) and Yigit (2007) have examined if introducing an inflation target has lowered the persistence and volatility of inflation. Johnson (2002, 2003), de Mello and Moccero (2006) and Cerisola and Gelos (2008) have evaluated the inflation target impact on the level of expected inflation. Holub and Hurník (2008) base themselves on the Czech data to examine creation of inflation expectations in general, Holub (2008) addresses the role of the target undershooting in inflation expectations, Babetskii, Coricelli and Horváth (2007) and Franta, Saxa and Šmídková (2007) have inter alia analysed the impact introducing the inflation target on inflation persistence.

<sup>2</sup> Another possible reason why the inflation expectations moved frequently below the inflation target may be seen in building-in of a significant exchange rate appreciation into the inflation expectations for 2002–2003. The foregoing channel is dealt with by the article “Inflation deviations from the CNB's targets – their reasons and impacts on the inflation expectations” in these proceedings.

<sup>3</sup> This restriction, in particular, disables a response of the inflation target to other variables; see the econometric model description in Section 2.

## 2. ECONOMETRIC MODEL DESCRIPTION

### 2.1 Vector error correction model

We have employed the vector error correction model (VECM) by Johansen and Juselius to evaluate the existence of a long-term relationship between the inflation target and inflation expectations, and other macroeconomic variables.

In the matrix form, the so-called reduced form VECM has the following form:

$$\Delta y_t = \mu + \Pi y_{t-1} + \sum_{i=1}^p \Pi_i \Delta y_{t-i} + \varepsilon_t \quad (1)$$

where  $y_t$  denotes the vector of variables,  $\varepsilon_t$  vector of residuals,  $\mu$  vector of constants and  $\Pi_i$  is the matrix of parameters to be estimated.<sup>4</sup> We estimate several specifications that differ depending on which variables are included in  $y_t$ . The simplest specifications include only the inflation expectations, target and actual inflation, while the most comprehensive ones include the following variables:  $y_t = [\pi_t^*, \pi_t^{com}, \pi_t^{food}, \Delta s_t, \pi_t, \pi_t^{exp}, i_t]$ .  $\pi_t^*$  denotes the CNB's inflation target (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, respective values are adopted from the CNB's main prediction model - the QPM),  $\pi_t^{com}$  represents commodity price inflation,  $\pi_t^{food}$  denotes foodstuff price inflation,  $\Delta s_t$  is the exchange rate change,  $\pi_t$  means the CPI inflation,  $\pi_t^{exp}$  denotes the market inflation expectations for 12, or, 36 months forward, and  $i_t$  means 3M PRIBOR.

### 2.2 Vector autoregression model under block restrictions

We have employed block restriction vector autoregression (Zha, 1999, Lutkepohl, 2005) to analyse short-term dynamic relations of the inflation target and inflation expectations – the model is defined as follows:

$$\begin{bmatrix} y_t^1 \\ y_t^2 \end{bmatrix} = \begin{bmatrix} A_{11}^1 & 0 \\ A_{21}^1 & A_{22}^1 \end{bmatrix} \begin{bmatrix} y_{t-1}^1 \\ y_{t-1}^2 \end{bmatrix} + \dots + \begin{bmatrix} A_{11}^1 & 0 \\ A_{21}^1 & A_{22}^1 \end{bmatrix} \begin{bmatrix} y_{t-p}^1 \\ y_{t-p}^2 \end{bmatrix} + \begin{bmatrix} e_t^1 \\ e_t^2 \end{bmatrix} \quad (2)$$

where vector  $y_t^1 = [\pi_t^*]$ , i.e. the vector includes only the CNB's inflation target, while vector  $y_t^2$  includes the remaining variables, i.e.  $y_t^2 = [\pi_t^{com}, \pi_t^{food}, \Delta s_t, \pi_t, \pi_t^{exp}, i_t]$ . The above block restriction prevents the inflation target from responding to the development of other variables.<sup>5</sup> The block

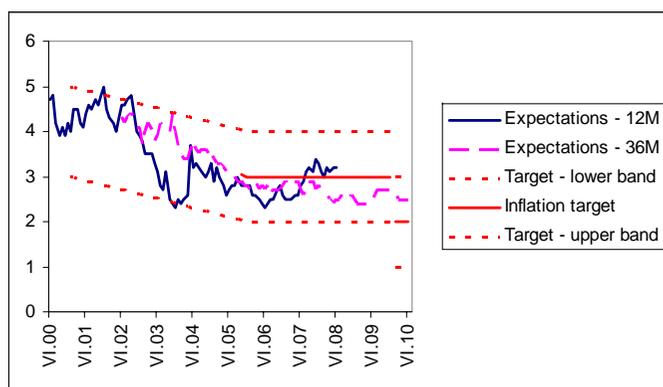
<sup>4</sup> We determine the VECM model lags in a standard manner, using the Schwarz information criterion (SIC). In our case, the number of lags equals 1 or 2, subject to specification of the variable vector.

<sup>5</sup> A similar set of variables has been used by Holub and Hurník (2008) that, too, has addressed the inflation expectations analysis, using a simple vector autoregression model. In our paper, we have additionally introduced an inflation target under block restrictions which enables us to explicitly analyse the inflation target impact on inflation expectations. Since monthly-frequency data are used in the empirical section, no explicitly cyclical element has been included in the variable vector. Otherwise, a quarterly output gap to the monthly frequency would have had to be interpolated in order to set up a time series that would contain 2/3 of “artificially” generated observations, which is particularly problematic in dynamic models of the VAR type, as

restriction consequently means that the other variables within vector autoregression, such as foodstuff inflation in month  $t-1$  cannot influence the level of inflation target in month  $t$ . This restriction is motivated by aiming at creating the inflation target exogenous in short-term to all other macroeconomic variables and to have a more realistic VAR model as a result. The advantage of the method consists in its lower demands for the degrees of freedom, as a smaller number of parameters are estimated. A publicly accessible CNB's ARAD database has been used as the data source (see [http://www.cnb.cz/cnb/STAT.ARADY\\_PKG.STROM\\_KOREN](http://www.cnb.cz/cnb/STAT.ARADY_PKG.STROM_KOREN)).

For this article, we have employed the monthly data from June 1999 to June 2007 on the financial market inflation expectations over the 12-month and 36-month horizons, from the surveys carried out by CNB.<sup>6</sup> The financial market inflation expectations over 12 and 36 months compared to the inflation target are shown in Figure 3. Obviously, the expectations have moved within the target, or, tolerance band in the long term, however the 36-month horizon expectations have stabilised under the point target. The question naturally is to what extent the inflation expectations held by the financial analysts may be taken as an indicator of the economy-wide inflation expectations. Given a high correlation (see Footnote 9) of the analyst inflation expectations and those of the corporate sector an assumption may be made that our employed expectations are representative of at least the corporate sector. The assumption is further supported by the estimate derived from the two-equation VAR model including inflation expectations of both companies and analysts and indicating that the analyst expectations have a statistically significant impact on the corporate expectations (the results may be obtained upon request).

**Figure 1: Inflation expectations (12- and 36-month horizon) and the inflation target**



Note: The inflation 12- and 36-month expectations have been shifted forward by 1 and 3 years respectively to compare with the CNB's inflation target.

such "artificially" set up observations would have been regressed for themselves. A procedure like that could induce the spurious regression problem. Industrial production used sometimes in the literature is too much volatile to reflect the cyclical conditions.

<sup>6</sup> No earlier data are available. CNB also carried out quarterly surveys of inflation expectations of firms and households. We do not use the latter data for several below reasons. Firstly, the survey is taken only quarterly which considerably limits the number of observations, econometric results of which would have been certainly adversely affected by that (much higher uncertainty of estimates). What is more, inflation expectations of the corporate sector are tightly correlated with the financial market expectations (the correlation has recorded 0.93 in our data sample). Inflation expectations of the households significantly diverge from reality and their correlation with future real inflation in our data sample was insignificant.

### 3. RESULTS

A long-term relationship (so-called cointegration vector) of the inflation expectations and other variables is presented in Table 1.<sup>7</sup> It is apparent from the Table that an increase of the inflation target by 1 pp was accompanied by a drop of inflation expectations by approx. 0.3–0.5 pp over 12 months. In the 36-month horizon, the estimate indicates a somewhat higher value, by about 0.6 pp. Further, we can see that a long-term relationship exists of the development of overall inflation and inflation expectations. In addition, Table 1 points to the fact that the exchange rate appreciation was accompanied by lower inflation expectations. It follows from the estimated coefficients that the exchange rate appreciation by 1 pp was accompanied by a drop of inflation expectations by approx. 0.03 or 0.04 pp, a surprisingly low impact. We can also see that the interest rate setting is related to the inflation expectations. Higher rates may be expected during the higher inflation expectation periods (even though the relationship is statistically insignificant for the 36-month horizon expectations). Foodstuff price inflation is not significant for the inflation expectations development in the long-term (while it is significant in the short term, see below). Commodity price inflation, too, appears not highly relevant for the inflation expectation creation in the long-term horizon (the relationship is not statistically significant in one case, while it is significant in another, but the estimated coefficient has the opposite sign), which is not exactly surprising given the variable's volatility.

**Table 1: Inflation expectations and the inflation target, a long-term relationship, 1999–2007**

	Inflation expectations - 12-month horizon			Inflation expectations - 36-month horizon		
	(1)	(2)	(3)	(4)	(5)	(6)
Inflation target	0.55*** [0.16]	0.32* [0.18]	0.33** [0.15]	0.58*** [0.02]	0.58*** [0.03]	0.62*** [0.15]
Commodity inflation			-0.01** [0.005]			-0.004 [0.003]
Foodstuff price inflation			-0.05 [0.04]			0.001 [0.05]
Rate change			0.03** [0.01]			0.04*** [0.01]
Inflation		0.45*** [0.12]	0.21** [0.08]		0.05** [0.02]	0.17** [0.08]
3M PRIBOR			0.37*** [0.11]			0.12 [0.10]
Number of observations	94	94	94	94	94	94

Note: Standard errors in the parentheses below the estimated parameter. \*, \*\*, \*\*\* denotes the significance at 10, 5 and 1 per cent level.

<sup>7</sup> Relevant tests have indicated the existence of a single cointegration vector.

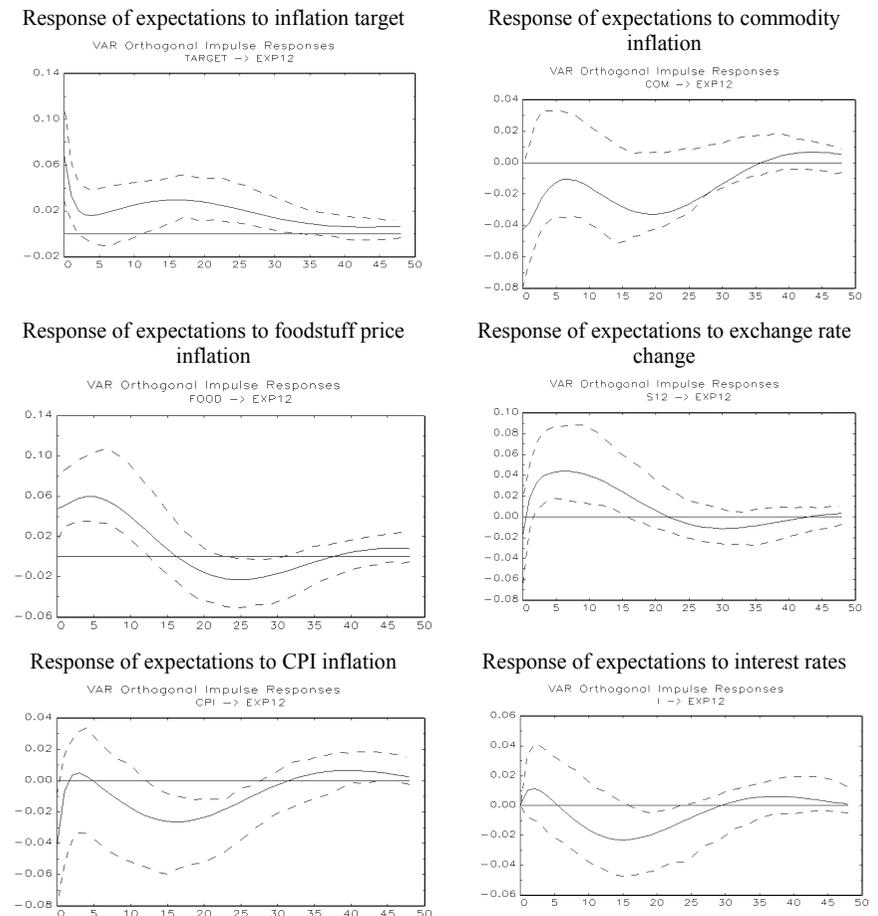
Next, we present estimates below for the above described block restriction VAR model, in a standard form of impulse responses and variance decomposition (as noted above, this model, as opposed to the previous model, is better suited to analyse short-term relationships). Figure 2 shows the impulse response by the inflation expectations to the shock caused by the remaining variables within our model. As the results imply, lower inflation target induce the inflation expectations to decrease in a statistically significant manner (see the image top left of the Figure), which suggests that the CNB's inflation target had been anchoring the financial market inflation expectations over the period under review (which supports the conclusions arrived to by Holub and Hurník, 2008).<sup>8</sup> An increase in commodity price inflation has no statistically significant impact on the inflation expectations (confidence intervals are too wide). Higher foodstuff price inflation leads to a short term increase in the inflation expectations (the increase is statistically significant over an approximate 12-month horizon). The VAR model results point also at the significance of the exchange rate fluctuations in creation of the inflation expectations. The exchange rate depreciation leads to higher inflation expectations: the effect is statistically significant approximately 3 or 9 months after the exchange rate shock. According to the results, a CPI inflation increase has initially no significant impact on the inflation expectations, while the inflation increase within approximately 18 months is accompanied by lower inflation expectations. This may reflect the fact that economic subjects expect lower inflation in future due to an expected response of the monetary policy to higher inflation. Similarly, a increase of interest rates is teamed with a significant decrease of the expectations as the market is expecting a drop in future inflation as a response to introducing a more restrictive monetary policy (once again, the response of the inflation expectations is significant after approx. 6 quarters, which presumably reflects perception of the CNB's monetary policy horizon). The foregoing, in addition to the inflation target effect on the inflation expectations, may be interpreted as another evidence of a credible monetary policy. The Appendix presents additional impulse responses (inflation response to the monetary policy shock and to the inflation target). The results indicate that a monetary restriction induces lower inflation, while a lower inflation target is accompanied by lower inflation.

In Figure 3, we present the results with the 36-month inflation expectations (the rest of the model remains unchanged). These results support to quite a degree interpretation of the result in Figure 2 (inflation expectations within the 12-month horizon). The inflation target has a systematic effect on the inflation expectations. The market shows somewhat surprising revaluation of its inflation expectations depending on the foodstuff prices even within the above horizon (although the impulse response is significant in the short term only). Current exchange rate fluctuations are impacting creation of the inflation expectations, exchange rate depreciation leads to a decrease in expected inflation (the effect presumably reflects the expectations of the financial market that the current exchange rate depreciation will result in higher inflation forecast by the central bank and that the bank will then respond by higher interest rates and those will subsequently reduce inflation with a

<sup>8</sup> A cumulative impulse response to the target was computed, too, and it indicates that reducing the target by 1 pp reduced the expectations by 0.35 pp one year after the shock, and, by 0.6 pp two years after. Cumulative responses showed a similarity even when the 36-month inflation expectations were used. Hence, the results do not on the overall support the “hypercredible” target hypothesis. Chow prediction tests were carried out in order to evaluate whether the CNB's migration from the conditional forecast to the unconditional one in mid-2002 caused any structural break in the migration expectations. Resulting tests do not dismiss the null hypothesis for either of the inflation expectation horizons – corresponding bootstrapped values recorded 0.21 and 0.78 respectively – and we have therefore found nothing in support of a structural break. The above VAR models have been estimated also based on the 1999M6–2006M1 data. The results remain practically unchanged vis-à-vis those presented in Figures 2 and 3. A reason of this sensitivity analysis lies in the fact that the inflation target value had not changed since 2006 and consequently had a zero variability.

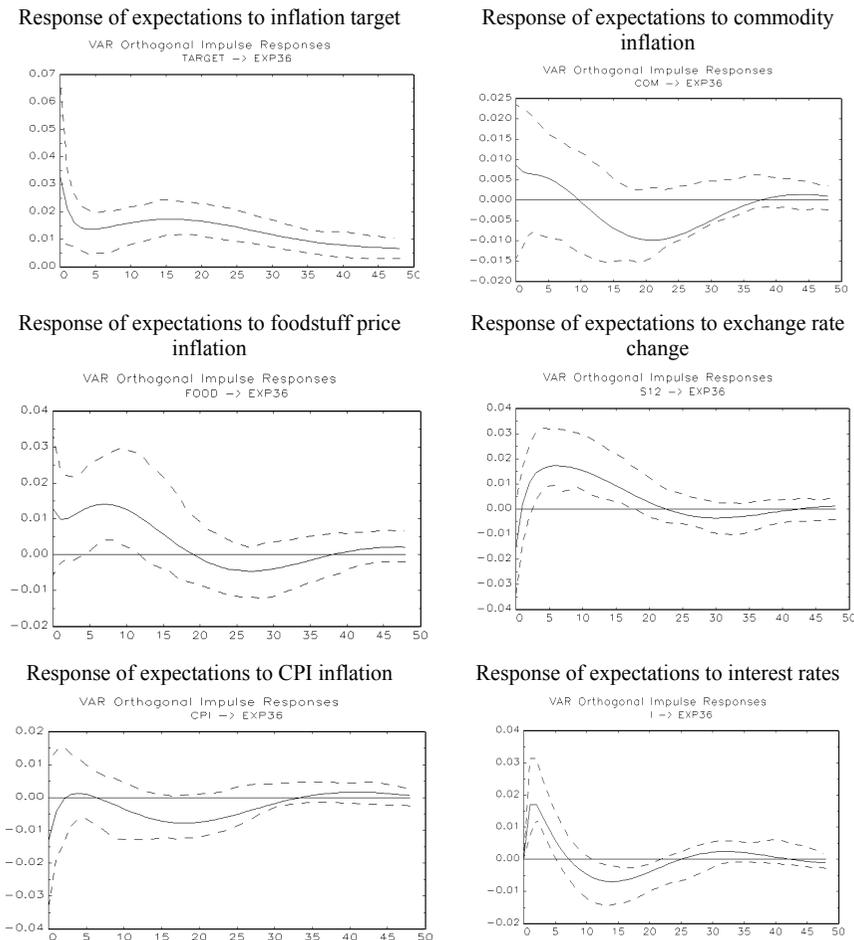
delay and accordingly also the 36-month inflation expectations). The development of current CPI inflation and the interest rate setting does not seem to be so important in terms of their impact on the 3-year ahead expectations.

**Figure 2: Inflation expectations (12-month horizon): Impulse responses, Block restriction VAR**



*Note: The x axis shows time in months. The full line shows the impulse response, the dashed lines represent a 95% confidence interval computed using the Efron bootstrap method (it may be said then that the inflation expectation response is statistically significant in a given month providing both of the confidence intervals are positioned either below or above the x axis). Identification of shocks uses the Cholesky decomposition.*

**Figure 3: Inflation expectations (36-month horizon): Impulse responses VAR under block restrictions**

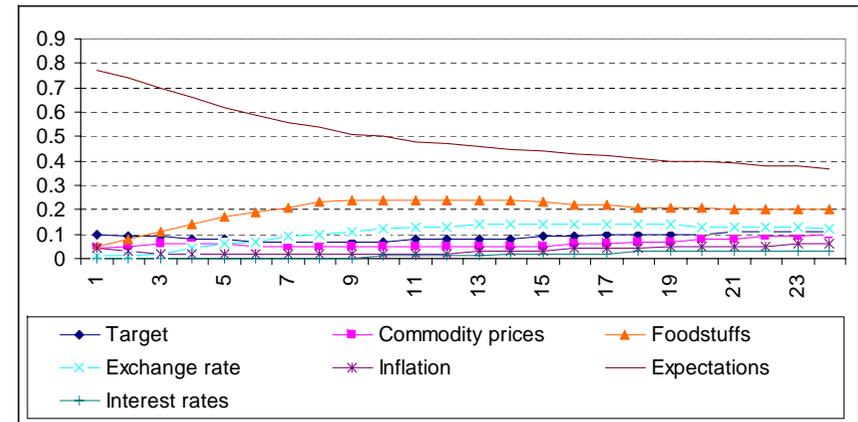


Note: The x axis shows time in months. The full line shows the impulse response, the dashed lines represent a 95% confidence interval computed using the Efron bootstrap method (it may be said then that the inflation expectation response is statistically significant in a given month providing both of the confidence intervals are positioned either below or above the x axis). Identification of shocks uses the Cholesky decomposition.

Figures 4 and 5 present variance decomposition for the inflation expectations within the 12- and 36-month horizon respectively. It follows from Figure 4 that the short-term variability of the 12-month inflation expectations is based on the foodstuff price inflation variability by approx. 20–25%, change of the inflation target by 10% and monetary conditions by 15% (the exchange rate significance exceeds that of the interest rates). A considerable relevance of the foodstuff prices for

creation of the inflation expectations is supported also by the newly available data from the turn of 2007–2008 that show an increase in the inflation expectations in the light of a high increase of the foodstuff prices. The significance of the commodity prices and overall inflation records less than 10%. It may be supposed due to the low impact of the commodity prices that the market did not expect any significant second-round effects of the commodity prices on inflation. The residual variability relates to the inflation expectations per se.

**Figure 4: Inflation expectations (12-month horizon): Variance decomposition, Block restriction VAR**

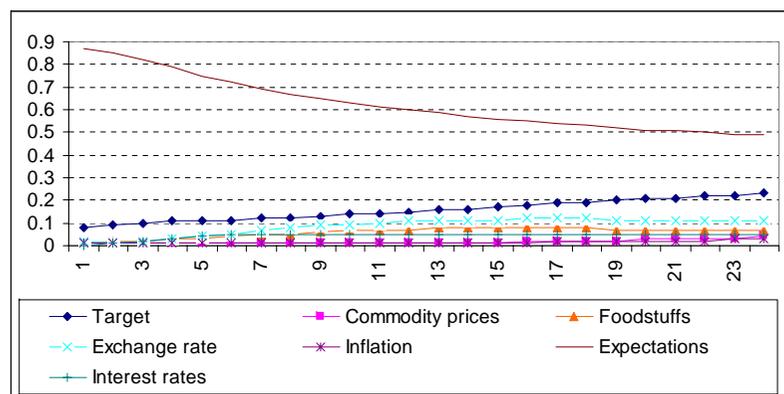


Note: The x axis shows time in months.

With respect to the inflation expectation variability over 36 months, we can see in Figure 5 that the significance of the foodstuff prices has dropped considerably (from the above 20–25% to the values below 10%).

The monetary conditions significance remains more or less unchanged, about 15%, and the same applies to other variables, except for the inflation target. The inflation target significance for the inflation expectations variability has increased from the above 10% to approx. 20%. An increase in significance of the inflation target therefore apparently indicates the credibility of the CNB's monetary policy, since the foodstuff price development has been identified as the most important short-term determinant, while the key longer-term determinant is represented by the inflation target that impacts the inflation expectations revaluation by the financial market. The residual variability, ranging to the high 50%, may be attributed to the inflation expectations per se. This, on one side, refers to the stability of the inflation expectations over the 36-month prediction horizon (the financial market “is not easily tempted to reevaluate its view on the inflation development for 3 years forward”), on the other side, it also suggests that our model is apparently somewhat more suitable for an analysis of the 12-month inflation expectations and that we could include additional factors describing the economic cycle into it.

**Figure 5: Inflation expectations (36-month horizon): Variance decomposition, VAR under block restrictions**



Note: The x axis shows time in months.

#### 4. CONCLUSION

This article initially addresses the role of the inflation target with respect to inflation expectations developments using the vector error correction model (VECM) and block restriction vector autoregression (VAR), based on the monthly data of 1999–2007. The econometric analysis performed has not identified any grounds in support of the “hypercredible” inflation target hypothesis, under which a 1 pp decrease would be accompanied by a decrease of inflation expectations by more than 1 pp. The results however suggest that the inflation target is a major determinant of inflation expectations, its significance for creating the inflation expectations surpassing even that of the current inflation development. Another conclusion is that the inflation expectations show a significant statistical decrease when responding to a stricter monetary policy and to the inflation target decrease. On the overall, the results indicate that the monetary policy has anchored the inflation expectations.

#### REFERENCES

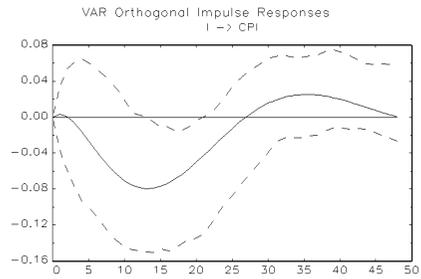
- BABETSKII, I., F. CORICELLI, AND R. HORVÁTH (2007): “Measuring and Explaining Inflation Persistence: Disaggregate Evidence on the Czech Republic,” Czech National Bank Working Paper, No.1.
- CERISOLA, M. AND G.R. GELOS (2008): “What Drives Inflation Expectations in Brazil? An Empirical Analysis,” *Applied Economics*, in print.
- DE MELLO AND D. MOCCERO (2006): “Monetary Policy and Inflation Expectations in Latin America: Long-Run Effects and Volatility Spillovers,” OECD Economics Department Working Papers, No. 518.
- FRANTA, M., B. SAXA, AND K. ŠMÍDKOVÁ (2007): “Inflation Persistence: Euro Area and New Member States,” European Central Bank, Working Paper, No. 810.
- HOLUB, T. (2008): “Odchylky inflace od cílů ČNB – jejich příčiny a dopady do inflačních očekávání” (Causes of Deviations of Inflation from CNB Targets – An Empirical Analysis), in this volume.
- HOLUB, T. AND J. HURNÍK, (2008): “Ten Years of Czech Inflation Targeting: Missed Targets and Anchored Expectations,” *Emerging Markets Finance and Trade*, in print.
- JOHNSON, D. (2002): “The Effect of Inflation Targeting on the Behavior of Expected Inflation: Evidence from an 11 Country Panel,” *Journal of Monetary Economics*, 49, 1521–1538.
- JOHNSON, D. (2003): “The Effect of Inflation Targets on the Level of Expected Inflation in Five Countries,” *The Review of Economics and Statistics*, 85(4), 1076–1081.
- LEVIN, A., F. NATALUCCI, AND J. PIGER (2004): “Explicit Inflation Objectives and Macroeconomic Outcomes,” European Central Bank Working Paper, No. 383.
- LUTKEPOHL, H. (2005): *New Introduction to Multiple Time Series*, Springer-Verlag, Berlin.
- MISHKIN, F. AND K. SCHMIDT-HEBBEL (2006): “Does Inflation Targeting Make a Difference?,” Czech National Bank Working Paper, No. 13.
- VEGA, M. AND D. WINKELRIED (2005): “Inflation Targeting and Inflation Behavior: A Successful Story?,” *International Journal of Central Banking*, 153–175.
- YIGIT, T. (2007): “Inflation Targeting: An Indirect Approach to Assess the Direct Impact,” Bilkent University Working Paper, No. 6/2007.
- ZHA, T. (1999): “Block Recursion and Structural Vector Autoregressions,” *Journal of Econometrics*, 90, 291–316.

**APPENDIX: ADDITIONAL IMPULSE RESPONSES**

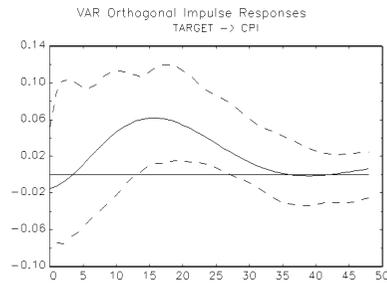
**Inflation expectations (12-month horizon): Impulse responses,**

**Block restriction VAR**

Response of inflation to interest rate



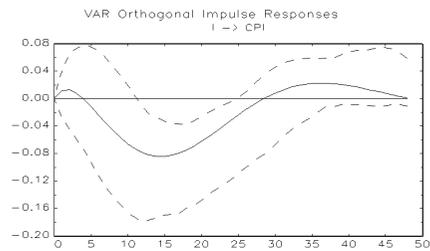
Response of inflation to inflation target



**Inflation expectations (36-month horizon): Impulse responses,**

**Block restriction VAR**

Response of inflation to interest rate



Response of inflation to inflation target

