

Undershooting of the Inflation Target in the Czech Republic: The Role of Inflation Expectations^{*}

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Abstract

This article addresses the role of the inflation target in inflation expectations using the vector error correction (VECM) and block restriction vector autoregression (VAR) models, based on the monthly data of 1999–2007 in the Czech Republic. The econometric analysis identifies nothing to support the “hypercredible” inflation target hypothesis, under which a 1 pp decrease in the inflation target would be accompanied by a decrease in inflation expectations of more than 1 pp. The results, however, do suggest that the inflation target is a major determinant of inflation expectations, its importance for the formation of inflation expectations surpassing even that of current inflation. Another conclusion is that inflation expectations decrease significantly in response to stricter monetary policy and to a lower inflation target. All in all, the results imply that Czech monetary policy has anchored inflation expectations.

1. Introduction

Inflation targeting was introduced in the Czech Republic ten years ago, yet there is still a comparatively limited number of empirical studies explicitly attempting any evaluation of whether and how this monetary policy regime has actually contributed to the anchoring of inflation expectations.¹ The primary purpose of this article is to estimate the extent to which the CNB’s inflation target and monetary policy have impacted on inflation expectations, particularly in relation to the frequent undershooting of the inflation target.

The “hypercredible” inflation target hypothesis, under which a 1 pp reduction in the inflation target would induce a decrease in inflation expectations of more than 1 pp in the long term, is one of the inflation target undershooting options. The lower

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

inflation expectations of economic agents would then contribute to inflation stabilization at values below the inflation target. The inflation target, according to our econometric analysis, is a major determinant of inflation expectations, although nothing has been found to support the “hypercredible” inflation target hypothesis.² Relying on the 1999–2007 data, our estimates indicate that a 1 pp reduction in the inflation target would on average be accompanied by a 0.4 pp drop in the financial market’s inflation expectations at the 12-month horizon and by a 0.6 pp drop at the 36-month horizon.

This article also addresses the nexus between inflation expectations, the target, and other macroeconomic variables over a short time period, using impulse response analysis and variance decomposition within the block restriction vector autoregression model.³ We identify a statistically relevant decrease in inflation expectations in response to a stricter monetary policy and to a lower inflation target. The econometric analysis performed indicates that the CNB’s monetary policy is credible overall. While the key determinant of inflation expectations is food prices in the short term, it is the inflation target that impacts on inflation expectations in the longer term. Overall, the results indicate that the CNB’s monetary policy has anchored 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 offers concluding remarks. An appendix with additional results follows.

2. Description of the Econometric Model

2.1 Vector Error Correction Model

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

In 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, ε_t represents the vector of residuals, μ denotes the vector of constants, and Π_i is the matrix of parameters to be estimated.⁴ We estimate several specifications that differ depending on which variables are included in y_t . The simplest specifications include only inflation expectations, the inflation target, and actual inflation, while the most comprehensive one includes the following variables: $y_t = [\pi_t^*, \pi_t^{com}, \pi_t^{food}, \Delta s_t, \pi_t, \pi_t^{exp}, i_t]$. π_t^* denotes the CNB’s inflation target (for the period during which the target was published only as a band, the mean

² Another possible reason why inflation expectations were frequently below the inflation target may be seen in the building-in of significant exchange rate appreciation into the inflation expectations for 2002–2003. This channel is dealt with in the article “Causes of Deviations from the CNB’s Inflation Targets: An Empirical Analysis” in this issue.

³ This restriction, in particular, disables any response of the inflation target to other variables; see the description of the econometric model in Section 2.

⁴ 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 the specification of the variable vector.

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), π_t^{com} represents commodity price inflation, π_t^{food} denotes food price inflation, Δs_t is the exchange rate change, π_t means CPI inflation, π_t^{exp} denotes market inflation expectations for 12 or 36 months ahead, and i_t means the 3M PRIBOR (the short-term interest rate).

2.2 Vector Autoregression Model under Block Restrictions

We employ the block restriction vector autoregression model (Zha, 1999, and Lutkepohl, 2005) to analyze the short-term dynamic relations of the inflation target and inflation expectations, with the model defined as follows:

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

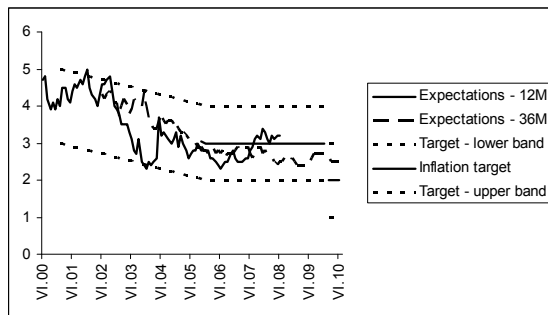
where vector $y_t^1 = [\pi_t^*]$, i.e., the vector includes only the CNB's inflation target, while vector y_t^2 includes the remaining variables, i.e., $y_t^2 = [\pi_t^{com}, \pi_t^{food}, \Delta s_t, \pi_t, \pi_t^{exp}, i_t]$.

The above block restriction prevents the inflation target from responding to other variables. The block restriction thus means that the other variables within the vector autoregression, such as food inflation in month $t-1$, cannot influence the level of the inflation target in month t . This restriction is motivated by the aim to make the inflation target exogenous in the 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 degrees of freedom, as a smaller number of parameters are estimated. The CNB's publicly accessible ARAD database was used as the data source (see http://www.cnb.cz/cnb/STAT.ARADY_PKG.STROM_KOREN).

A similar set of variables was used by Holub and Hurník (2008). They, too, conducted an 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 analyze the impact of the inflation target on inflation expectations. Since monthly data are used in the empirical section, no explicitly cyclical element has been included in the variable vector. Otherwise, the quarterly output gap would have had to be interpolated to monthly frequency in order to set up a time series, two-thirds of which would consist of “artificially” generated observations. This is particularly problematic in dynamic models of the VAR type, as such “artificial” observations would be regressed on themselves. A procedure like that could induce the spurious regression problem. Industrial production, which is sometimes used in the literature, is too volatile to reflect the cyclical conditions.

For this article, we employed monthly data from June 1999 to June 2007 on financial market inflation expectations over the 12-month and 36-month horizons, taken from surveys carried out by the CNB.⁵ The financial market inflation expectations 12 and 36 months ahead compared to the inflation target are shown in *Figure 1*. The expectations have long moved within the target or tolerance band, but

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.

the 36-month horizon expectations have stabilized under the point target. The attendant question obviously is to what extent the inflation expectations of financial analysts may be taken as an indicator of economy-wide inflation expectations. Given the high correlation (see footnote 5) between the financial analysts' inflation expectations and those of the corporate sector, an assumption may be made that the expectations we employ are representative of at least the corporate sector. This assumption is supported by an estimate derived from the two-equation VAR model including the inflation expectations of both companies and financial analysts. This indicates that the analysts' expectations have a statistically significant impact on corporate expectations (the results may be obtained upon request).

3. Results

The long-term relationship (the so-called cointegration vector) between inflation expectations and other variables is presented in *Table 1*.⁵ The results suggest that an increase in the inflation target of 1 pp was accompanied by an increase in inflation expectations of approximately 0.3–0.5 pp at 12 months. For the 36-month horizon, the estimate indicates a somewhat higher value of about 0.6 pp. Furthermore, we can see that a long-term relationship exists between overall inflation and inflation expectations.

In addition, *Table 1* shows that exchange rate appreciation is accompanied by lower inflation expectations. It follows from the estimated coefficients that an exchange rate appreciation of 1 pp was accompanied by a drop of inflation expectations of around 0.03 or 0.04 pp, a surprisingly low impact. We can also see that the interest rate setting is related to inflation expectations. Higher rates may be expected during periods of higher inflation expectations (even though the relationship is statistically

⁵ No earlier data are available. The CNB also carried out quarterly surveys of the inflation expectations of firms and households. We do not use the latter data for several reasons. Firstly, the survey is conducted only quarterly, which considerably limits the number of observations; the econometric results would certainly be adversely affected by that (higher uncertainty of the estimates). What is more, the inflation expectations of the corporate sector are highly correlated with financial market expectations (a correlation of 0.93 in our data sample). The inflation expectations of households are imprecise and their correlation with future real inflation in our data sample was insignificant.

⁶ Relevant tests indicate the existence of a single cointegration vector.

TABLE 1 Inflation Expectations and the Inflation Target, 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

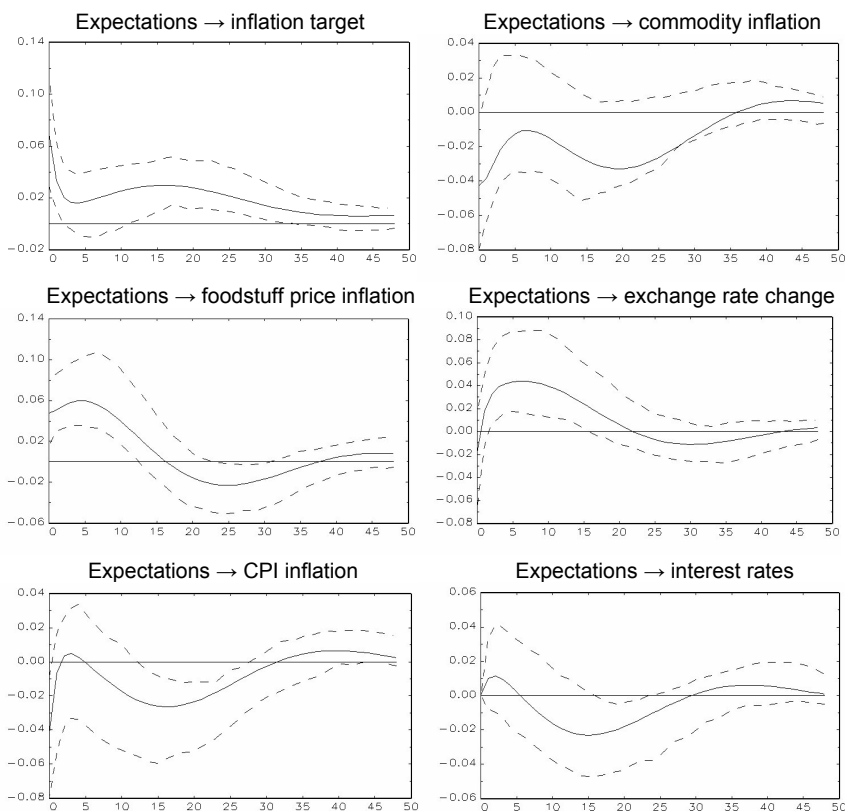
Note: Standard errors in parentheses below the estimated parameter. *, **, *** denote significance at the 10, 5, and 1 per cent level, respectively.

insignificant for the 36-month horizon expectations). Food price inflation is not significant for inflation expectations in the long term (although it is significant in the short term – see below). Commodity price inflation, too, appears to be not highly relevant for the formation of inflation expectations in the long term (the relationship is not statistically significant in one case, while it is significant in the other, but the estimated coefficient has the opposite sign), which may reflect the variable’s volatility.

Next, we present estimates below for the above-described block restriction VAR model, in the standard form of impulse responses and variance decomposition (as noted above, this model, as compared to the previous model, is better suited for analyzing short-term relationships). *Figure 2* shows the impulse response of inflation expectations to the shock caused by the remaining variables within our model. As the results imply, a lower inflation target induces inflation expectations to decrease in a statistically significant manner (see the top left of the chart), which suggests that the CNB’s inflation target anchored financial market inflation expectations over the period under review (in line with (Holub, Hurník, 2008)).⁷ An increase in commo-

⁷ The cumulative impulse response to the target was computed, too. It indicates that reducing the target by 1 pp reduced expectations by 0.35 pp one year after the shock and by 0.6 pp two years after. The cumulative responses were similar even when the 36-month inflation expectations were used. Hence, the results do not support the “hypercredible” target hypothesis overall. Chow prediction tests were also carried out in order to evaluate whether the CNB’s move from the conditional forecast to the unconditional one in mid-2002 caused any structural break in the expectations. The results do not reject the null hypothesis of no structural break for either of the inflation expectation horizons – the corresponding bootstrapped *p*-values were 0.21 and 0.78, respectively. The above VAR models were also estimated based on the 1999M6–2006M1 data. The results remain practically unchanged vis-à-vis those presented in *Figure 2* and 3. The reason for this sensitivity analysis lies in the fact that the inflation target value had not changed since 2006 and consequently had zero variability.

FIGURE 2 Inflation Expectations (12-month horizon): Impulse responses, Block restriction VAR

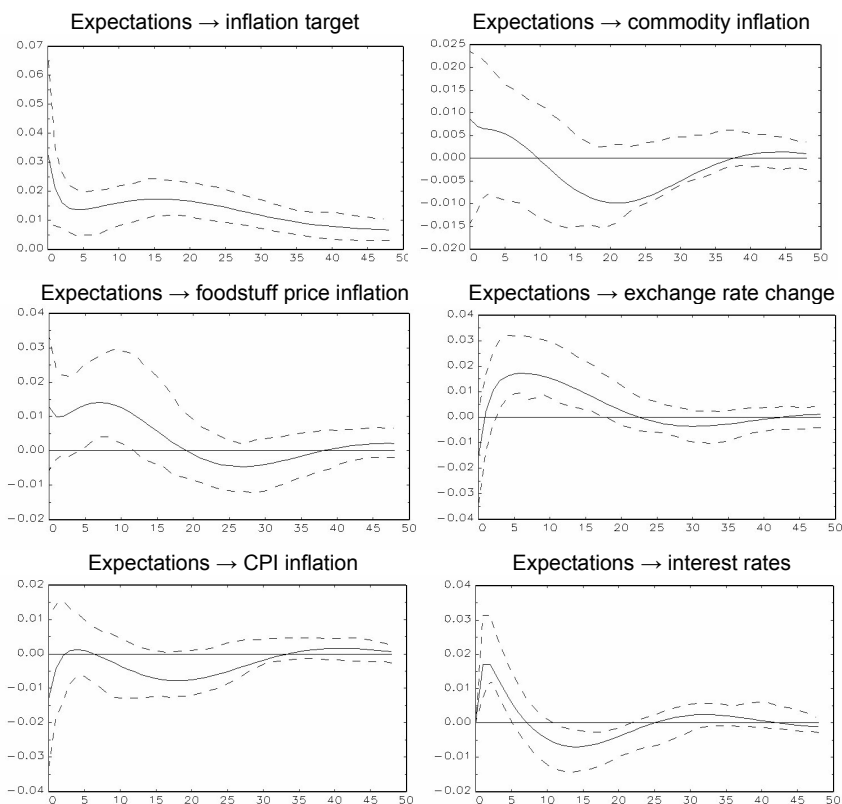


Note: The x axis shows time in months. The full line shows the impulse response, the dashed lines represent a 95% confidence interval computed using the Efron bootstrap method (it may be said then that the inflation expectation response is statistically significant in a given month providing both of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

dity price inflation seems to have no statistically significant impact on inflation expectations (the confidence intervals are too wide). Higher food price inflation leads to a short-term increase in inflation expectations (the increase is statistically significant over an approximately 12-month horizon).

The VAR model results point also to the significance of exchange rate fluctuations in the formation of inflation expectations. An 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, an increase in CPI inflation initially has no significant impact on inflation expectations, while an increase in inflation within approximately 18 months is accompanied by lower inflation expectations. This may reflect the fact that economic agents expect lower inflation in the future due to the expected monetary policy response to the higher inflation. Similarly, an increase in interest rates is associated with a significant decrease in expecta-

FIGURE 3 Inflation Expectations (36-month Horizon): Impulse Responses
VAR under Block Restrictions

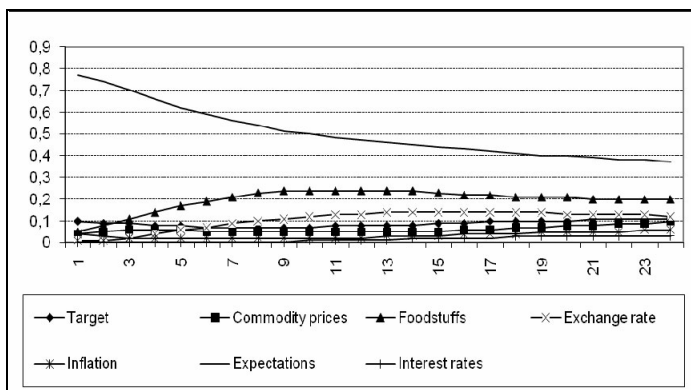


Note: The x axis shows time in months. The full line shows the impulse response, the dashed lines represent a 95% confidence interval computed using the Efron bootstrap method (it may be said then that the inflation expectation response is statistically significant in a given month providing both of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

tions, as the market expects a drop in future inflation in response to a more restrictive monetary policy (once again, the response of inflation expectations is significant after approximately 6 quarters, which presumably reflects the perception of the CNB's monetary policy horizon). All in all, in addition to the effect of the inflation target on inflation expectations, this may be interpreted as evidence of credible monetary policy in the Czech Republic. The appendix presents additional impulse responses (the response of inflation to a 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.

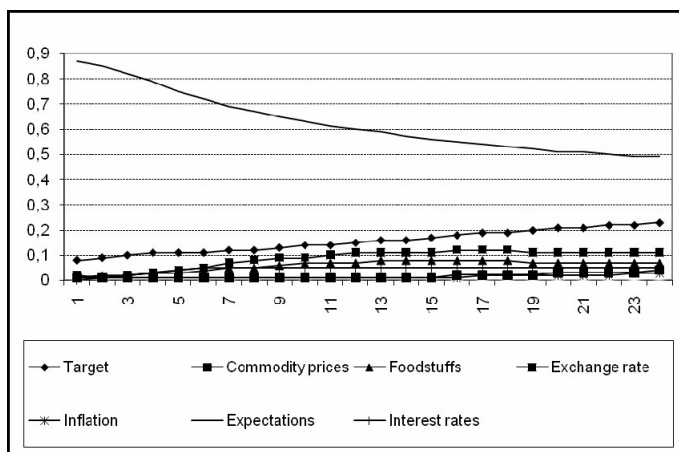
In *Figure 3*, we present the results with the 36-month inflation expectations (the rest of the model remains unchanged). These results largely support the interpretation of the results in *Figure 2* (inflation expectations at the 12-months ahead horizon). The inflation target has a systematic effect on inflation expectations. Market

FIGURE 4 Inflation Expectations (12-month Horizon): Variance decomposition, block restriction VAR



Note: The x axis shows time in months.

FIGURE 5 Inflation Expectations (36-month Horizon): Variance Decomposition, VAR under block restrictions



Note: The x axis shows time in months.

inflation expectations surprisingly react to food prices even for the 36-month horizon (although the impulse response is significant only in the short run). Current exchange rate fluctuations impact on inflation expectations; an exchange rate depreciation leads to an increase in expected inflation. Current CPI inflation does not seem to be so important in terms of its impact on the 3-years ahead expectations. The results indicate that a contractionary monetary policy shock induces lower inflation expectations with a lag of about one or one and a half years.

Figures 4 and 5 present the variance decomposition for inflation expectations within the 12- and 36-month horizons, respectively. It follows from Figure 4 that the short-term variability of 12-month inflation expectations is based on food price

inflation variability by approximately 20–25 %, change in the inflation target by 10 %, and the monetary conditions by 15% (the importance of the exchange rate exceeds that of interest rates). The considerable relevance of food prices for the formation of inflation expectations is supported by newly available data from late 2007 and early 2008, which show an increase in inflation expectations in the light of high growth in food prices. The significance of commodity prices and overall inflation is less than 10 percent. It may be supposed due to the low impact of commodity prices that the market did not expect any significant second-round effects of commodity prices on inflation. The remaining variability relates to the inflation expectations themselves.

With respect to the 36-months ahead inflation expectation variability, the results in *Figure 5* suggest that the significance of food prices has dropped considerably (from above 20–25 % to below 10 %). The significance of the monetary conditions remains more or less unchanged at about 15 %, and the same applies to the other variables except for the inflation target. The significance of the inflation target for the inflation expectations variability has increased from above 10 % to approximately 20 %. The increase in significance of the inflation target therefore apparently indicates that the CNB's monetary policy is credible, since food price inflation has been identified as the most important short-term determinant, while the key longer-term determinant is the inflation target. The remaining variability, accounting for a high 50 %, may be attributed to inflation expectations per se. This, on the one side, reflects the stability of the 36-months ahead inflation expectations (the financial market "is not easily tempted to re-evaluate its view on the inflation development for 3 years forward"). On the other hand, it also suggests that our model is apparently somewhat more suitable for analyzing 12-month inflation expectations and that we could include in it additional factors assessing the business cycle.

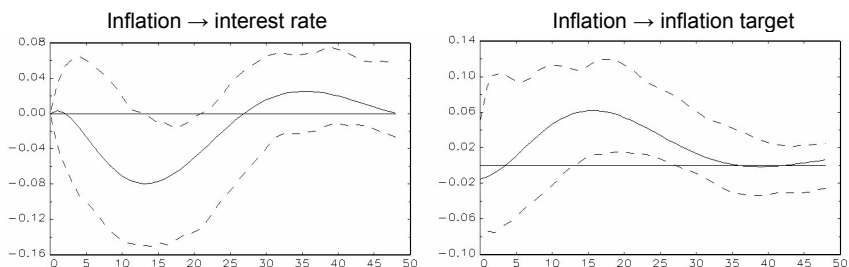
4. Conclusion

This article addresses the role of the inflation target in inflation expectations using the vector error correction model (VECM) and block restriction vector autoregression (VAR), based on the monthly data of 1999–2007. The econometric analysis identifies nothing to support the "hypercredible" inflation target hypothesis, under which a 1 pp decrease in the inflation target would be accompanied by a decrease in inflation expectations of more than 1 pp. The results, however, do suggest that the inflation target is a major determinant of inflation expectations in the long run, its significance for the formation of inflation expectations surpassing even that of current inflation. Another conclusion is that inflation expectations show a statistically significant decrease when responding to stricter monetary policy and to a decrease in the inflation target. All in all, the results indicate that Czech monetary policy has anchored inflation expectations.

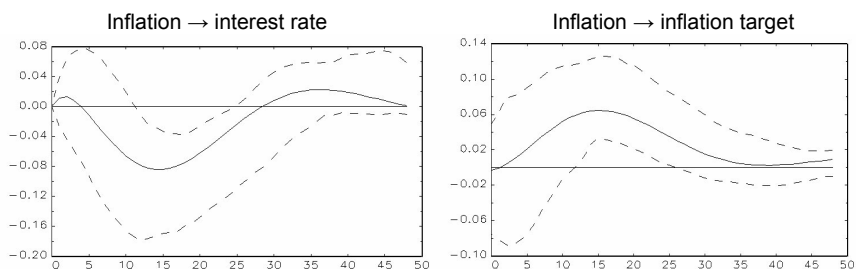
APPENDIX

Additional Impulse Responses

Inflation Expectations (12-month Horizon): Impulse Responses, Block Restriction VAR



Inflation Expectations (36-month Horizon): Impulse Responses, Block Restriction VAR



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