CHAPTER 4

CAUSES OF DEVIATIONS OF INFLATION FROM CNB TARGETS – AN EMPIRICAL ANALYSIS

TOMÁŠ HOLUB

1. INTRODUCTION

This paper offers an empirical analysis of the causes of deviations of inflation from the CNB targets during the first ten years of inflation targeting. Section 2 presents a review of such causes as contained in the existing literature dealing with inflation targeting in the Czech Republic, and it applies a simple cross-correlation analysis and Granger causality tests to identify which explanatory variables – and with what time lag – seem to have a statistically significant relationship to such deviations of inflation from the target. Section 3 then offers estimates of two VAR models examining impulse responses of the deviations of inflation from the target to the individual shocks, and a variance decomposition of these deviations.

Based on those analyses, it can be concluded that the most important short-term factor of deviations of inflation from the target are the shocks relating to prices of agricultural producers. In the medium-term horizon, however, the development of the real exchange rate gap unequivocally takes over as the most important factor. The main common macro-economic feature of the two periods of the most significant undershooting of inflation targets indeed was a noticeable and unexpected strengthening of the exchange rate of the Czech crown. Difficulties caused by the exchange rate were further accentuated by the coincidence with other factors, although these were less significant and – as such – they would have probably only resulted in a less distinct and merely short-term undershooting of inflation targets. The analysis, however, does not provide an answer to the question of why the target fulfilment was asymmetrically skewed in the undershooting direction and why the periods characterised by depreciation corrections of the exchange rate did not see any overshooting of the CNB targets.

2. LITERATURE REVIEW AND BASIC STATISTICAL TESTS

Fulfilment of the CNB targets in the course of the first decade of inflation targeting was affected to a significant extent by two episodes characterised by noticeable undershooting of the targets, namely in the years 1998–99 and 2002–03. The existing literature has consented on a list of the relevant causes of such distinct target undershooting (see e.g., Kotlán and Navrátil, 2003; Geršl and Holub, 2006). They involved declining food prices (in both periods), low oil prices (in both periods), a pause in deregulations (in 2002–03), fiscal and monetary restrictions (in 1998–99), a growth slow-down in the EU (in 2002–03), and strengthening of the exchange rate of the Czech crown (in both periods). To compare, the CNB assigned in its Inflation Reports the 1998–99 target undershooting in the first place to the food prices, and then to the weak local demand, strong exchange rate, and low oil prices in 1998. In the years 2002–03, the CNB pointed out particularly to the disinflationary effects of regulated prices, food prices, appreciation of the exchange rate, and the international developments.

A disadvantage regarding the above-described papers lies – with the exception of the CNB Inflation Reports – in that they would not quantify the relative importance of the individual factors. At the same time, they do not take into consideration any endogenous links of those factors, such as, e.g., the effect of the exchange rate, the monetary and fiscal policy or international developments on the local food prices and on regulated prices, as well as the feedback effects of the price developments on the monetary policy decisions. Without considering such links, any quantification would be difficult, something which throws a shade of doubt also on the analysis of both of the two periods as presented in the Inflation Reports. The CNB forecasts were compiled for both of those periods

using short-term forecasting methods, and they were also assessed with these tools afterwards concerning their fulfilment. Those methods were not particularly suitable for capturing any medium-term endogenous relations in the economy (see Coats, et al., 2003). The existing QPM model was not used until mid-2002, i.e. until the second exchange rate appreciation episode was already peaking. Therefore, it was possible to use it in the analysis of the causes of deviations of inflation from the target (see Filáček, 2007; Antoničová, et al., 2008) only starting at the beginning of 2004 when inflation already commenced to return to the target.

Holub and Hurník (2008) express the opinion that the exchange rate development was the common key feature of both of the two target undershooting episodes. For the sake of brevity, however, no sufficiently detailed evidence for such claims has been presented, and/or, such evidence is only mentioned in a footnote. The present paper removes the above-described shortcomings and brings about a detailed empirical analysis of the causes of the deviations of inflation from the target.

The cited papers – despite their shortcomings – may help us compile a list of variables to be further examined as regards their statistical and economic significance in the explanation of deviations of inflation from the target. More specifically, this paper focuses on the following variables: the real exchange rate, agricultural producer prices, crude oil prices in USD, foreign and domestic economic activity, and domestic real interest rates.

All variables have been used on a quarterly basis in the form of their deviations from estimated equilibrium levels, because the variable in focus – i.e., deviations of inflation from the target[1] – may also be considered as deviations from the equilibrium. As far as prices of crude oil and agricultural producer prices are concerned, they always represent deviations from the trend as estimated with help of the Hodrick-Prescott (HP) filter.[2] In the event of the real exchange rate gap, real interest rates gap, and domestic and foreign output gaps, we work with two alternative estimates. The first one is based the structural Kalman Filter, which has been applied by the CNB in its analyses and forecasts (see Beneš and N'Diaye, 2003); the other one is based on the HP Filter. The advantage in using the Kalman Filter is in that the estimated "gap" values correspond to the view of the central bank concerning the development of the Czech economy. On the other hand, however, its application may cause certain distortions in the analyses in the form of an implicit "a priory" presumption about the course of monetary transmission as captured by the QPM model applied by the CNB. The application of an alternative estimate with help of the HP Filter, which represents a non-parametric filter, therefore, may be understood as robustness check of the results.[3]

All the applied data and estimates correspond to the CNB forecast as published in its Inflation Report I/2008, and cover the first ten years of inflation targeting, i.e., the period of time from the first quarter of 1998 until the fourth quarter of 2007.

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[1] In the period 1998–2001, this is a deviation of net inflation from the middle of the target, which had been extrapolated in a linear manner into the individual quarters from the year-end values. As far as the later period is concerned, talk goes here of deviations of the headline inflation from the middle of the target range, or the CNB point target.

[2] We also tried to use year-on-year changes instead of deviations from the H-P trends because unexpected changes of those prices may cause a deviation of inflation from the target irrespective of whether they concern shifts in the long-term equilibrium or temporary fluctuation. However, the results were similar in quality, so we do not present them in the subsequent text.

[3] As concerns the real interest rates gap, there also exists a difference in that – as regards the Kalman filter – nominal rates have been deflated by partly forward-looking expectations, while inflation expectations in the event of the HP filter have been deemed as purely backward-looking.

Testing of statistical significance of the above-described variables was first made with help of a simple cross-correlation analysis and Granger causality pair-wise tests. One of the variables was always represented by deviations of inflation from the target, while the other side was always occupied by one of the above-described explanatory variables. The results are reported in Table 1. The results of both tests are always shown for the time lag which would maximise the value of the correlation coefficient, or the probability level of the Granger causality test.

All of the above-described explanatory variables have a statistically significant and in the majority of cases economically intuitive correlation with the deviations of inflation from the target with a time lag ranging from "zero" (for agricultural producer prices) up to 10 quarters (for foreign output gap). In the event of real exchange rate, the time lag amounts to three quarters; in the event of real interest rate gap it reaches 0-2 quarters (depending on the method of calculation). The only surprising outcome is the long lag and the sign attached to the foreign output gap, which runs counter to the economic intuition, indicating that the correlation may be spurious rather than reflecting a true causal relationship.

All of the explanatory variables, with the exception of agricultural producer prices[4] and the real interest rate gap estimated with help of the HP Filter, at the same time, Granger-cause the deviations of inflation from the target at least at the 10-percent significance level, usually with a time lag of 1-2 quarters (only with the foreign output gap the time lag would extend to 10 quarters, in line with the correlation analysis, making this relationship hard to interpret). These results, therefore, justify further research of relationships between those variables and the deviations of inflation from the target.

Table 1: Factors of inflation deviations from target – cross-correlation analysis and Granger causality tests

Explanatory variables	Correlation coefficient [1, 2]	Granger causality test – probability[2]
Foreign output gap – KF	-0.40* (10)	4.0 % (10)
Foreign output gap –HP	-0.44* (10)	5.1% (10)
Oil prices	0.51* (3)	0.8% (1)
Real exchange rate gap - KF	-0.59* (3)	0.0% (1)
Real exchange rate gap - HP	-0.52* (3)	0.0% (1)
Agricultural producer prices	0.58* (0)	14.1% (1)
Output gap – KF	0.55* (0)	0.5% (2)
Output gap – HP	0.47* (1)	5.4% (1)
Real interest rate gap – KF	-0.51* (2)	0.0% (0)
Real interest rate gap – HP	-0.75* (0)	14.1% (4)

Source: Own calculations.

*Notes: HP denotes estimates produced with help of the HP Filter, KF denotes estimates produced with help of the Kalman Filter; 1) * denotes statistically significant results at the 5% probability level. 2) The numbers in brackets show the time lag between explanatory variables and the deviations of inflation from the target maximising the statistical significance of the identified relationship.*

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[4] The statistical insignificance of agricultural producer prices has probably resulted from the fact that the relationship – according to the performed correlation analyses (and in line with empirical experience) – was contemporaneous, which cannot be captured by definition by the Granger causality test.

Also examined was the reverse correlation and causality directed from inflation deviations from the target to the analysed variables, which – however – is not presented in Table 1 for the sake of brevity. The reverse causality was statistically significant at least at the 10% probability level with almost all variables, with the exception of the foreign output gap estimated with help of the Kalman Filter. In the case of oil prices, which can be deemed as a purely exogenous factor, this conclusion is not very intuitive. It can be presumed – in view of the small time lag – that it rather represents a co-incidence of both variables than any causal relationship. In the case of domestic variables, however, the option of a reverse causality is not surprising and it only confirms opinions expressed in the introduction to this Section, namely that a number of factors used in the literature so far to explain deviations of inflation from the target is in reality of an endogenous nature, which needs to be considered in the analysis.

3. ESTIMATES OF VAR MODELS

Consideration of the endogenous links among the individual variables can be performed by way of estimates of the VAR models, which are presented in the present Section. Those VAR models at the same time allow for the identification of not only the statistical significance of the individual factors with help of examining impulse responses to shocks, but also for an analysis of the economic significance via a variance decomposition of the deviations of inflation from the target. More specifically, two models have been estimated, which can be expressed in general as follows:

$$Y_t = aLY_t + v_t \tag{1}$$

$$Y_t = [ea\_gap_t, poil\_gap_t, er\_gap_t, czv\_gap_t, gdp\_gap_t, pi\_gap_t, ir\_gap_t] \tag{2},$$

where *ea_gap* denotes the foreign output gap (approximated by the effective eurozone, i.e., with the individual countries weighed according to their shares in the Czech foreign trade), *poil_gap* denotes the deviation of the USD crude oil price from the equilibrium, *er_gap* denotes deviation of the real exchange rate from the equilibrium, *czv_gap* denotes deviation of agricultural producer prices from the equilibrium, *gdp_gap* denotes the domestic output gap, *pi_gap* denotes deviation of inflation from the target, *ir_gap* denotes the real three-month interest rate gap, while v_t means the vector of residuals and *L* stands for the lag operator. Both of the models differed only in one sense: whether they included the gaps of foreign and domestic demand, the real exchange rate, and real interest rate estimated with help of the Kalman Filter or the HP Filter.
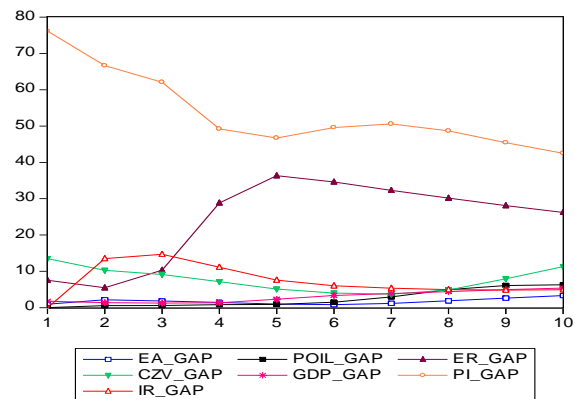
Shocks to the individual variables were identified in a standard manner on the basis of the Cholesky decomposition, with the variables ordered according to Equation (2). This is a fairly standard ordering, which corresponds to the view of the transmission of shocks in a small open economy applying inflation targeting. The ordering means an implicit presumption that shocks to exogenous variables (*ea_gap* and *poil_gap*) may have an immediate impact on the exchange rate of the Czech crown, rather than the other way round. The exchange rate, together with the agricultural producer prices and the domestic output gap may then directly affect inflation deviations from the target which, however, does not influence immediately the said variables. The monetary policy then responds, under the inflation targeting regime and via the set-up of the interest rates, to the

development of all available information. The lag length in the model was determined at 2 quarters, in view of the relatively short time series and making use of the standard tests.[5]

A variance decomposition of the deviations of inflation from the target is presented in Figure 1 for the VAR model making use of estimates made with help of the Kalman Filter, and in Figure 2 for the model with the input variables estimated with help of the HP Filter.
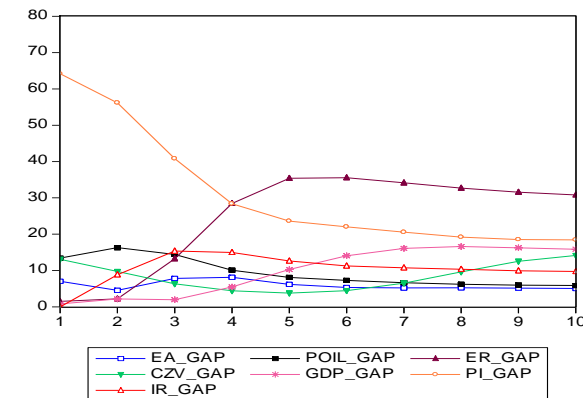
It has turned out that in the short term the most important factors of the deviations of inflation from the target (apart from the shocks to inflation itself) are represented by the agricultural producer prices and – in the case of the model making use of estimates based on the HP Filter – also the crude oil prices. Their influence, however, would get weaker in the longer run. Shocks to the real interest rates, i.e. monetary policy shocks, hold roughly a 15-percent share in both models on the variance of the deviations of inflation from the target on the horizon of approx. 2-4 quarters, and that share is at the edge of statistical significance. However, on the horizon of one year and longer, the outspokenly most distinct factor is represented by the real exchange rate gap, which explains a substantially larger portion of the variance of the deviations of inflation from the target (over 35 %) than the other macro-economic variables, and its influence is statistically significant. As far as the model making use of the HP Filter is concerned, the shocks to the domestic output gap are also at the edge of statistical significance on the horizon exceeding 6 quarters; the model based on the time series derived from the Kalman Filter, however, would not support this conclusion.

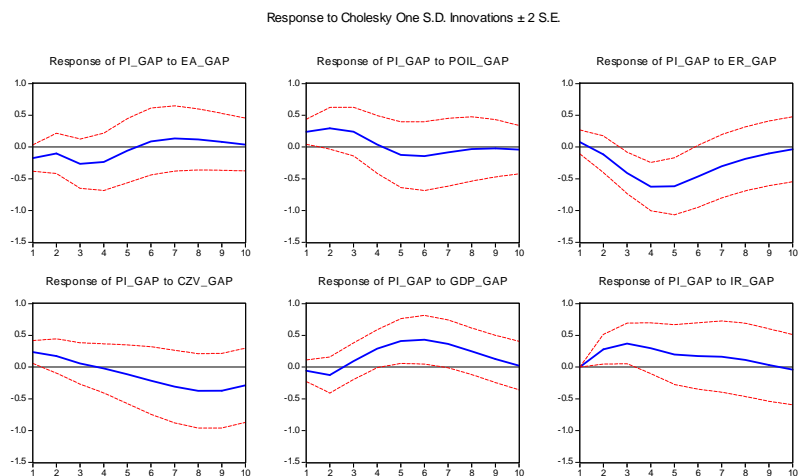**Figure 1: Variance decomposition of the deviations of inflation from the target (Kalman Filter)**

Figure 2: Variance decomposition of the deviations of inflation from the target (HP Filter)

The impulse responses of the deviations of inflation from the target to shocks affecting the individual variables are shown in Figure 3 for the model using variables derived from the Kalman Filter and in Figure 4 for the model using variables derived from the HP Filter. Some conclusions would be qualitatively identical for both models. Shocks hitting the agricultural producer prices are statistically significant for short time lags; however, their impact would gradually decline and would quickly become statistically insignificant. The real exchange rate shocks are most effective with a lag of 4-5 quarters, and an overvaluation (undervaluation) of the real exchange rate results in a statistically significant decline (increase) of inflation below (above) the target. The maximum real exchange rate pass-through into inflation equals roughly 28–38%, which approximately matches the conclusions from the previous studies applicable to the Czech Republic (see Babestkaia, 2007).[6] Both of the models also consent that international demand shocks would not have any statistically significant impact on the deviations of inflation from the target. The said conclusions, therefore, may be considered as reasonably robust.

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[5] The application of the Schwarz criterion would result in preference of only one quarter; using the Akaike information criterion would require the application of time lags in excess of two quarters, which would be facing limitations in the form of short time series. Under this situation, a lag of two quarters was selected as a compromise solution. We also examined the robustness of our results with respect to the selection of a shorter time lag, which appeared to be satisfactory.

[6] Usually, the pass-through of nominal exchange rate shocks to inflation would be analysed, with results slightly lower than the figures quoted here. However, under the presumption that a portion of the exchange rate shock would be reflected in inflation with a delay shorter than one quarter, it is required to have more than a proportionate shock to the nominal exchange rate to change the real exchange rate.

Figure 3: Impulse responses of deviations of inflation from the target to shocks (Kalman Filter)

Response to Cholesky One S.D. Innovations ± 2 S.E.
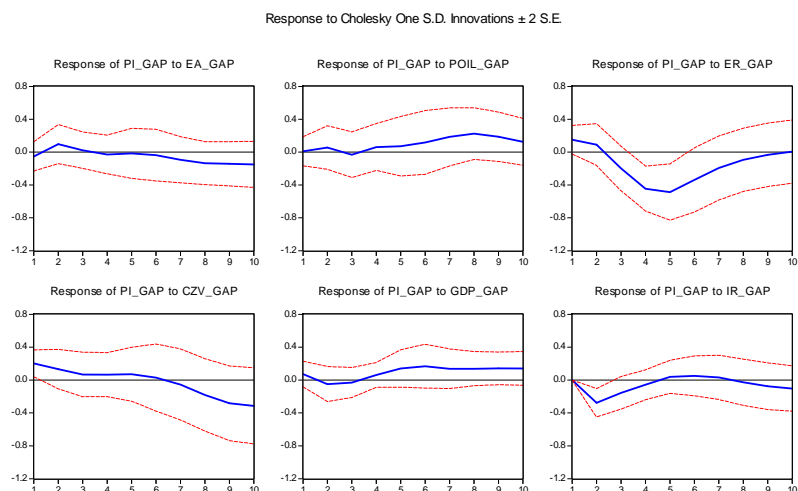
Figure 4: Impulse responses of deviations of inflation from the target to shocks (HP Filter)

Response to Cholesky One S.D. Innovations ± 2 S.E.

However, some partial differences exist between the two estimates, which urge for cautiousness in the interpretation of their results. The model applying inputs from the HP Filter identified shocks hitting the global crude oil prices as statistically significant for short-time lags, while the model with the Kalman Filter did not. The same applies in the medium-term horizon also for the impact of domestic output gap shocks, which is surprising – among other things – also in view of the fact that the output gap estimated with help of the Kalman Filter, contrary to the HP Filter, explicitly considers the relationship between this unobservable variable and inflation. The last noteworthy difference relates to the influence of real interest rates, which are statistically significant in both cases but – contrary to expectations – only in the short horizons of 2-3 quarters and, moreover, in both of the models with the opposite sign (an intuitive one in the model with inputs from the Kalman Filter, and an counter-intuitive one in the model with inputs from the HP Filter). Such results can most probably be assigned to the existence of certain general difficulties concerning the identification of the monetary transmission with help of the VAR models (see for example, the discussion in Arnoštová and Hurník (2005) and the references contained in this paper), and to uncertainties in the measuring of real interest rates (forward-looking vs. backward looking inflation expectations).

4. CONCLUSION

The results presented here thus show on the whole that the most important role in relation to the deviations of inflation from the target was probably played by the exchange rate. This reflects the fact that the main common feature of the two most important periods of undershooting of the inflation targets in the years 1998–99 and 2002–03 was represented by a significant and unexpected strengthening of the exchange rate of the Czech crown (roughly by 8 % towards DEM, and by 15 % towards euro, respectively). The difficulties caused by the exchange rate were further accentuated by certain concurrence with other short-term factors, including in particular the development of agricultural producer prices and probably also the development of the crude oil prices. Those factors, though, were of lesser significance and they would probably in themselves have resulted only in less distinct and shorter episodes of inflation targets undershooting.[7]

Based on the econometric methods applied, it is not possible to prove or exclude that the monetary policy in itself would create any significant shocks contributing to the non-fulfilment of inflation targets. In any case, it seem obvious at least that the monetary policy did not respond to exchange rate developments sufficiently quickly and strongly to prevent distinct episodes of non-fulfilment of inflation targets. In the first place, it attempted to restrain the scope of appreciation by foreign exchange interventions, the effect of which – however – proved to be fairly small and could not prevent the occurrence of relatively long periods of the exchange rate overvaluation (see Geršl and Holub, 2006). At the same time, the CNB – like a number of other analysts – may have underestimated the strength of the exchange rate pass-through into inflation.[8] It is also possible to express intuitively the hypothesis that in particular in the first of the above-described "troubled"

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[7] It remains an open question whether the given concurrence was only a coincidence or whether it was caused by some hidden causal factors. For example, the development of the global economy could have affected the prices of crude oil, the global prices of food as well as the development on the foreign exchange markets.
[8] In the first of the said periods, the short-term forecasting methods were applied, which – however – could hardly have a sufficient guidance in the data from the period of fixed exchange rate; in the other case, the exchange rate pass-through into inflation in the newly introduced QPM model was expertly restrained due to a lack of confidence in sufficient downward flexibility of prices.

periods, monetary policy in itself could contribute to the appreciation of the foreign exchange rate, when it was keeping the nominal interest rates high and the real interest rates in a restrictive position, even though the currency crisis was already fading out. It cannot be excluded that such policy may have been based also on certain asymmetry of the preferences of the CNB concerning the announced inflation targets, i.e., higher concerns regarding their overshooting than their undershooting as a result of the understanding of inflation targeting as a means for achieving disinflation and obtaining credibility, or any other monetary policy goals (e.g., efforts for the overall stabilisation of the situation after the preceding currency crisis).

Similarly, it is not possible to find out with help of the selected approach why the non-fulfilment of the target was on average significantly skewed towards its undershooting and, for example, no overshooting of the targets occurred during the periods of exchange rate depreciation.

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