Inflation Target Fulfillment in the Czech Republic in 1998–2007: Some Stylized Facts[*]

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Abstract

This paper provides some stylized facts of inflation target fulfillment in the Czech Republic in 1998–2007. In the first part, it discusses briefly the general macroeconomic conditions of the Czech inflation targeting regime, including an identification of the main shocks affecting its performance. The second part compares the extent of inflation target non-fulfillment in the Czech Republic with the experience of other inflation targeting countries. It turns out that the success rate in terms of inflation target fulfillment has changed over time. While in the early phase of inflation targeting the deviations of inflation from the CNB's targets were high by international comparison, more recently the CNB has converged to the track record of relatively successful inflation targeting central banks.

1. Introduction

This paper provides some stylized facts of inflation target fulfillment in the Czech Republic in the ten-year period 1998–2007. The first part of the paper starts in Section 2 by briefly indicating some general macroeconomic conditions of the Czech inflation targeting regime, including an identification of the main shocks affecting its performance. This basic description is followed in Section 3 by a discussion of the extent of target (non-)fulfillment in various phases of inflation targeting in the Czech Republic. The fulfillment of the target is evaluated using several statistics, such as the average deviation from the target and its *t*-test, the Root Mean Square Error (RMSE), and the percentage of the time that inflation was under the target. Target fulfillment is also evaluated using a hypothetical central bank loss function.

The second part of the paper then provides in Section 4 a comparison of the extent of inflation target non-fulfillment in the Czech Republic with the experience of several other inflation targeting countries. Using some basic descriptive statistics and graphical illustrations, our goal is to provide some stylized facts about the course of deviations from the inflation targets in some selected countries. This approach may inspire a more formal analysis of the shocks that have affected inflation in the individual countries. If we discover any common traits in the deviations

of inflation from the targets across individual countries, this may signal a potential common source of such deviations. That may provide information on whether the extent of the target non-fulfillment in the Czech Republic is comparable to other countries, and/or it could help us identify periods of major global shocks that affected all the countries implementing inflation targeting.

The conclusion of the paper (Section 5) can be summarized as follows. The challenges related to the achievement of the monetary policy goals were concentrated within two periods of time (1998–1999 and 2002–2003), which were marked by episodes of exchange rate appreciation. These exchange rate appreciation episodes were very strong and their consequences were persistent, so the occurrence of two such episodes in less than ten years could have caused a deviation in the direction of target undershooting on average (at the same time, however, it is hard to explain why no target overshooting took place during the period of exchange rate depreciation and pro-inflationary shocks). Moreover, the periods characterized by a strengthening of the exchange rate were combined with some other anti-inflationary factors, some of which were of a global nature.

A changing success rate in terms of inflation target fulfillment also emerges when one compares the various phases of inflation targeting in the Czech Republic. While the deviations of inflation from the targets were very high by international comparison in the early phase of inflation targeting, the Czech National Bank (CNB) has lately come closer to the track record of the relatively successful inflation targeting central banks. This may have resulted from a process of "learning," whereby the CNB has gradually been applying more advanced approaches in its monetary policy process. At the same time, it may be the outcome of a generally more stable macroeconomic situation in the Czech Republic as compared with the initial years of inflation targeting.

The CNB does not stand out significantly in the group of emerging market inflation targeting central banks as far as the frequency and extent of missing the target tolerance band is concerned. However, it has a specific (although not unique) position due to having undershot the target on average, with the empirical distribution of the deviations of inflation from the target being significantly asymmetric. Our analysis shows that the periods of the most extensive target undershooting in the Czech Republic (1998–1999 and 2002–2003) also correspond fairly well to the periods characterized by the most frequent occurrence of negative deviations of inflation from the target among the group of economies monitored. It seems, therefore, that the Czech Republic, at least to a certain extent, suffered from global anti-inflation shocks in these periods.

2. Macroeconomic Developments and Target Fulfillment over the Past Ten Years

Prior to evaluating the performance of the inflation targeting regime in the Czech Republic, it is useful to briefly mention the general macroeconomic context of inflation targeting in the Czech Republic (*Table 1*). The CNB announced its first inflation target in December 1997.[1] The beginning of inflation targeting was marked by

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[1] For arguments in favor of introducing inflation targeting in the Czech Republic, see (Hrnčíř, Šmídková, 1998a, 1998b). The introduction of inflation targeting was also discussed in detail in (Čihák, Holub, 1998).

TABLE 1 Basic Macroeconomic Indicators of the Czech Republic

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Real GDP growth rate	-0.7	-0.8	1.3	3.6	2.5	1.9	3.6	4.5	6.4	6.4	6.5
Year-on-year CPI inflation	10.0	6.8	2.5	4.0	4.1	0.6	1.1	2.8	2.2	1.7	5.4
Interest rates (3M PRIBOR)	17.6	9.5	5.5	5.4	4.6	2.6	2.1	2.6	2.2	2.6	4.1
Year-on-year exchange rate change CZK/USD [a]	26.7	-13.8	20.5	5.1	-4.1	-16.9	-14.9	-12.8	9.9	-15.1	-13.4
Year-on-year exchange rate change CZK/EUR [a,b]	9.9	-7.6	3.4	-2.9	-8.9	-1.2	2.6	-6.0	-4.8	-5.2	-3.2
Unemployment (Labour Force Survey)	5.4	7.3	9.0	8.3	7.8	7.3	8.1	8.2	7.8	6.5	4.8
Balance of payments (in % of GDP) Current account	-6.2	-2.0	-2.4	-4.8	-5.3	-5.5	-6.2	-5.2	-1.6	-3.1	-2.5
of which: Trade balance	-8.6	-4.2	-3.2	-5.5	-5.0	-2.9	-2.7	-0.5	2.0	2.0	3.3
Balance of services	3.1	3.1	2.0	2.5	2.5	0.9	0.5	0.6	1.2	1.3	1.6
Incomes balance	-1.4	-1.8	-2.2	-2.4	-3.6	-4.7	-4.7	-5.6	-5.2	-6.2	-7.1
Foreign Direct Investment	2.2	5.8	10.4	8.7	8.9	11.0	2.1	3.6	9.4	3.2	4.4

Source: Czech Statistical Office, Czech National Bank.

Notes: [a] A positive/negative value represents year-on-year depreciation/appreciation.
[b] The CZK/DEM exchange rate change for 1997–1999.

the aftermath of the financial turbulence that had occurred in the spring of 1997 and by the related challenging overall macroeconomic situation (high inflation as well as inflationary expectations, despite high interest rates, a drop in real GDP, depreciation of the exchange rate, and high trade deficits).[2] The certain "backward-lookingness" or "cautiousness" of monetary policy in that period, therefore, could have meant that any improvement in the situation as compared with the period of turbulence (in 1998 an appreciating exchange rate of the koruna and an improved trade balance, renewal of foreign direct investment inflows, a drop in interest rates as well as inflation, etc.) would have resulted in material non-fulfillment of the targets in 1998 and 1999.

A partial recovery in economic growth in 1999 and 2000 was followed by a renewed slowdown, connected, among other things, with excessive appreciation of the koruna at the end of 2001 and in 2002 combined with low international demand. This appreciation was caused, *inter alia*, by a strong inflow of foreign direct investment and market expectations of future major privatizations. Although the CNB's response to the appreciation was fairly strong,[3] the exchange rate movement was so large that a further significant undershooting of the inflation target could not be prevented.

However, foreign direct investments realized in 2003–2007 contributed to an acceleration of economic growth, a drop in unemployment as well as an improved trade balance. The trade balance has recorded surpluses ever since 2005, despite continued appreciation of the Czech koruna's exchange rate. The improvement in the overall macroeconomic situation over the past five years has also been to a large extent by the positive effects of the Czech Republic's accession to the EU at the beginning of 2004. Examples of such positive effects include an improved institutional environment in the Czech Republic, better access to EU markets, and a further strengthening of capital inflows from the EU.

3. Extent of Target Non-fulfillment and Its Development over Time

Figure 1 shows the development of inflation as compared with the CNB's targets. It shows that the CNB introduced inflation targeting at a time of relatively high inflation,[4] and one of the main intentions behind its introduction was to achieve disinflation and reduce inflation expectations (Hrnčíř, Šmídková, 1998a,b). In this respect, the monetary policy of the CNB can be assessed as relatively successful in the early inflation targeting phase, since the high inflation faded quickly. Subsequently, the CNB mostly undershot the target in the first ten years of inflation target-

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[2] For a more detailed discussion of the causes and consequences of the financial turbulence, see, for example, (Šmídková et al., 1998) or (Dědek, 2000).

[3] The CNB two-week repo rate dropped from 5.25 % at the beginning of November 2001 to 2 % as of 1 August 2003 (that is, below the level prevailing in the eurozone). The CNB performed fairly extensive interventions in the foreign exchange market in 2001–2002 (for a description and an analysis of the effectiveness of these foreign exchange interventions, see, for example, (Geršl, Holub, 2006), and the exchange rate appreciation was also addressed by purchases of privatization revenues into the CNB's foreign exchange reserves – see, for example, (CNB, 2002).

[4] In 2008, inflation has moved substantially above the target due to a combination of administrative measures (increases in indirect taxes and regulated prices) and higher international commodity prices. This fact is not reflected in this paper, as it focuses on the first ten years of the inflation targeting regime, i.e., from 1998 to 2007.

FIGURE 1 Inflation – targets vs. reality
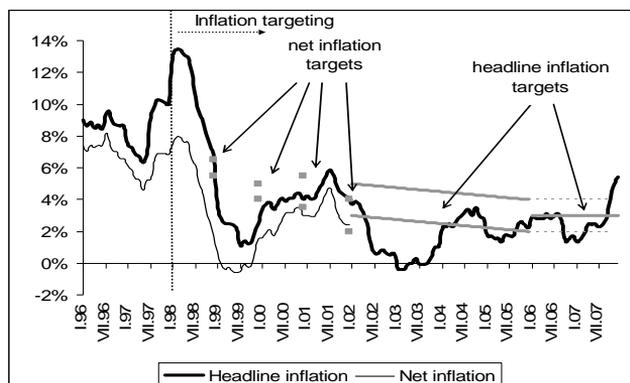
Source: Czech Statistical Office and CNB estimates.

ing, while overshootings occurred only in exceptional cases. The undershooting was most pronounced at the end of both 1998 and 1999, and in 2003. Out of the four net inflation targets, (the first) two were substantially undershot, one was moderately undershot, and (the last) one was fulfilled. So far, the headline inflation targets have been undershot in just over one half of cases (37 cases in 72 months), while inflation has fluctuated below the middle of the target band (65 cases in 72 months) for most of the time.[5]

    Table 2 shows the descriptive statistics of inflation target fulfillment, including a breakdown into the main periods of inflation targeting. The table shows that inflation was on average roughly 1.7 percentage points below target for the entire inflation targeting period. The extent of the undershooting was more significant in the net inflation targeting period (2.5 percentage points) than in the headline inflation targeting period (1.3 percentage points). The "Root Mean Square Error" (RMSE) statistic, which reflects the average target undershooting as well as inflation volatility, is 2.5 % for the entire period (3.3 % for the net inflation period, and 2.0 % for the headline inflation period).[6] The average deviation of inflation from the target for the entire inflation targeting period is statistically significant at the 1% level when the standard *t*-test is applied. This standard test, however, is based on the assumption of an independent random distribution of the individual observations, which does not hold in practice, as the deviations of inflation from the target are significantly auto-correlated. Therefore, an AR(2) process[7] for the time series of deviations from the target was estimated, and the statistical significance of the (negative) constant in the auto-

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[6] See also (Holub, Hurník, 2008).

[7] The AR(1) process was not sufficient to remove auto-correlation of the residuals. This is because the deviations of inflation from the target, in the event of major shocks, tend to increase for some initial time before turning and gradually disappearing. This dynamic is better described by an AR(2) process, as is confirmed by the statistical significance of the AR(2) term at the 1% significance level.

TABLE 2 Deviations of Inflation from the Target – Basic Statistics

	Period	Num-ber of obser-vations	Ave-rage devi-ation	Stan-dard error	Root Mean Square Error	Ratio of cases in %			
						Under the tar-get mid--point [c]	Under the band	In the band	Above the band
Inflation targeting – total [a]	1/99––12/07	109	-1.74	1.80	2.51	90.83	59.63	37.61	2.75
Net inflation [a]	12/98––12/01	37	-2.53	2.14	3.32	91.89	75.68	21.62	2.70
Headline inflation	1/02––12/07	72	-1.34	1.44	1.96	90.28	51.39	45.83	2.78
Prior to introduction of QPM [b]	1/02––7/03	19	-2.71	1.36	3.04	100.00	78.95	21.05	0.00
After introduction of QPM [b]	8/03––12/07	53	-0.84	1.10	1.39	86.79	41.51	54.72	3.77
Monetary-policy relevant inflation	1/02––12/07	72	-1.61	1.24	2.03	97.22	66.67	31.94	1.39

Notes: [a] The "December" net inflation targets had to be linearly extrapolated into the separate months, subject to equal reduction of the target in the course of each year.
[b] The QPM model was introduced in mid-2002; given monetary policy lags estimated at 4–6 quarters, we deemed the "QPM period" to commence in August 2003 (that is, with a lag of about 5 quarters).
[c] The ratio of cases "above the target mid-point" complements the ratio of cases under the target mid--point up to 100 %.

regressive process was analyzed as an alternative test. The constant was identified as statistically significant at the 5% probability level. This evidence speaks against the hypothesis of shocks skewed in the anti-inflationary direction, although we should point out that this is a very mechanical statistical test which in fact assumes symmetrically distributed shocks (see below for a discussion) and does not analyze any causal links.[8]

Table 2 also indicates a gradual improvement in target fulfillment over the various phases of inflation targeting in the Czech Republic. In the initial phase, the CNB introduced targeting of "net inflation," i.e., inflation net of deregulation and changes in indirect taxes.[9] The subsequent phase may be described as a transition to headline inflation targeting, motivated, among other things, by the better comprehensibility of this inflation measure to the public (CNB, 2001). In the last phase, which can be formally linked to the introduction of a more sophisticated model apparatus applied by the CNB since 2002,[10] the practice of inflation targeting in the Czech Republic has been close to the "best practice" in those countries where inflation targeting has a long tradition. Besides the above-mentioned introduction of higher-quality prognostic tools, the progress has also involved better quality support-

[8] The outcome may also depend on the data sample chosen. Note that if the first three quarters of 2008 were added to reflect the high inflation that year, the constant in the estimated AR(2) process would turn statistically insignificant at the common probability levels.

[9] For a definition of the net inflation target, see (CNB, 1999). The recently published "Transcripts of the Bank Board Meetings" (CNB, 2008) represent a unique opportunity to get insight into the decision--making of the CNB regarding the formulation of its monetary policy in that period.

ing statistical and econometric analyses, improved communication by the CNB as well as improvements in the entire monetary policy decision-making process.

Following the change in targeting from net inflation to headline inflation, the average target undershooting increased slightly (the average deviation from the target rose from -2.5 % to -2.7 %), as did the frequency of target undershooting (an increase from 75.7 % to 79 % of cases under the target band). This can be explained to a certain extent by a larger number of headline inflation items outside the reach of monetary policy as against net inflation (regulated prices, indirect taxes), which immediately after the switch to headline inflation targeting surprised the CNB in the downward direction due to declining global energy prices. However, the extent of the target undershooting declined substantially during the last, i.e., advanced phase of inflation targeting.[11]

It is interesting – but not surprising – to note that if we apply so-called monetary-policy relevant inflation[12] when measuring deviations of inflation from the target, the average target undershooting is higher than the evaluation based on headline inflation (an average deviation of -1.6 % as against -1.3 % for headline inflation). This situation ensues from the fact that tax changes made in the past resulted, in the overwhelming majority of cases, in increased inflation, and thus brought (low) headline inflation closer to the target. In the following text, however, we do not mention monetary-policy relevant inflation for two reasons. Firstly, it would disturb the international comparability of the results for the Czech Republic because all international comparative studies are based on comparisons of the officially targeted price indices with the declared targets, and they do not consider any potential *ex ante* escape clauses from target fulfillment. Secondly, the application of escape clauses has changed over the course of the inflation targeting period in the Czech Republic and it would be difficult to approach it in a consistent manner.[13]

The fact that the extent of target undershooting has changed over time is also obvious from the comparison of the target fulfillment indicators in the individual years (*Figure 2*). It shows a significant fluctuation in the success rate of inflation target fulfillment. In 1999, 2002, and 2003, a significant worsening occurred in terms of hitting the target, but on the other hand inflation came closer to the target in 2001 and 2004–2007.[14] Despite the rather significant volatility of the target fulfillment indicators, the figure also indicates the above-described trend of gradual improvement in target fulfillment over time.

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[10] The QPM (Quarterly Prediction Model), introduced in May 2002, is a so-called "unconditional model" comprising also an estimate of the future interest rate path (for a description of the model in its original form, see (CNB, 2003); for partial changes to the model, see (CNB, 1998–2007). The previous models were "conditional models" which assumed a constant level of interest rates. See, for example, (Skořepa and Kotlán, 2003) for a discussion of these issues.

[11] Note that if January–September 2008 was added to the data sample, the average target undershooting would be -0.2 percentage points in the advanced inflation targeting phase, i.e., not significantly different from zero.

[12] Monetary-policy relevant inflation represents inflation to which monetary policy reacts *ex ante*. It is defined as headline inflation adjusted for the first-round effects of changes to indirect taxes.

[13] For example, in 2002–2005, there was the option of applying an *ex ante* escape clause to the contribution of regulated prices to inflation falling outside the interval of 1–1.5 percentage points. If such an escape clause was taken into consideration, it would reduce the extent of target undershooting in 2002–2003, which is something we do not opt for in this analysis.

FIGURE 2 Target Fulfilment Indicators in the Individual Years
(average values of the indicators in the individual months of a given year)
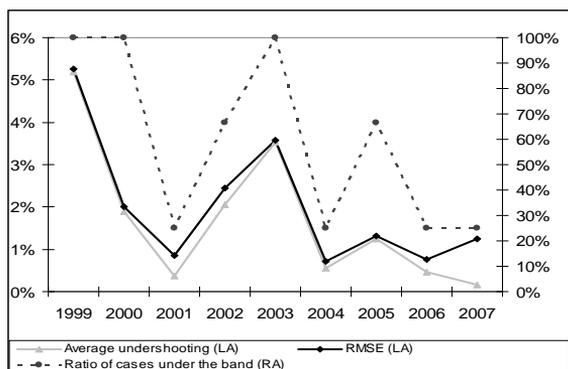
The time dimension of target undershooting will also emerge if we interpret the inflation targeting period with help of the values of a hypothetical central bank loss function (Kotlán, Navrátil, 2003). In line with the standard assumptions contained in the economic literature concerning central bank preferences under flexible inflation targeting, the applied loss function weights the square of the deviations of inflation from the target and the square of the output gap.[15] Both components of the loss function are depicted in *Figure 3a*, which shows a clear relationship between the extent of inflation target undershooting and the alternative estimates of the output gap;[16] any significant undershooting of the target was typically linked to a widening of the negative output gap, while convergence to the target was accompanied either by a closing of the negative output gap or an opening into positive values. Calculations of the loss function values for $\alpha = 3/4$ are shown in *Figure 3b*. They confirm the pre-

[14] The strong correlation between the RMSE indicator and the average target undershooting in a given year results from the fact that the CNB overshot its inflation target only in exceptional cases, and to a very minor extent. The moderately differing developments of these indicators in 2007 result from the inflation target overshooting at the end of 2007, which reduced the average target undershooting but had an upward impact on the RMSE indicator.

[15] The loss function was specified as follows: $L_t = \alpha.(\pi_t - \pi_t^{TAR})^2 + (1-\alpha).(y_t - y_t^*)^2$, where α depicts the weight of the deviations of inflation from the target, $(1-\alpha)$ the weight of the output gap, π_t^{TAR} the inflation target, π_t inflation, and $(y_t - y_t^*)$ the output gap. It is possible to see in the literature loss functions with other variables as well (see, for example, (Kotlán, Navrátil, 2003)). The simplest approach would only consider inflation, where the value of the loss function corresponds to the RMSE indicator. On the other hand, the loss function may also incorporate exchange rate volatility, interest rate volatility, unemployment, etc., besides the output gap. In this paper, we included only the output gap in the loss function. The applied higher weight of inflation as against the output gap reflects the logic of inflation as the main goal of monetary policy. The responsibility of monetary policy to contribute to economic stability is stipulated in the legislation only as a secondary goal which the CNB is supposed to meet only subject to the fulfillment of its main goal (see section 2(1) of Act No. 6/1993, on the Czech National Bank, as amended). The results, however, are fairly robust with respect to the selection of that parameter. Also note that the actual loss function could have changed over time as the composition of the Bank Board has changed.

[16] We applied three output gap estimation methods: simple smoothing using the Hodrick-Prescott (HP) filter with the parameter $\lambda = 1,600$, an estimate of the output gap with the help of the production function method (see (CNB, 2005)), and an estimate of the output gap as used in the QPM core prediction model, which is done with the help of the Kalman filter method (see (Beneš ,N'Diaye, 2003)).
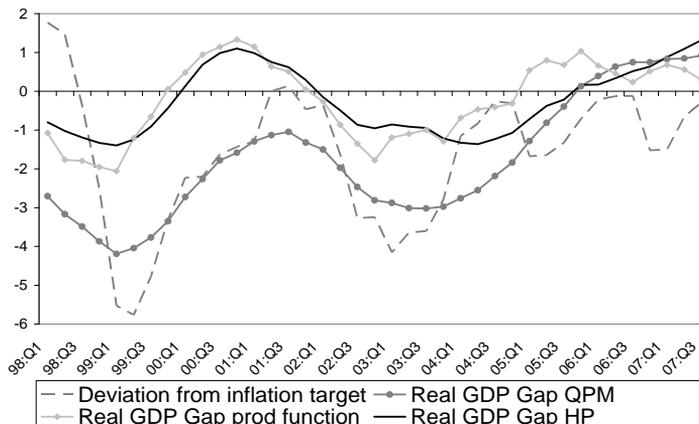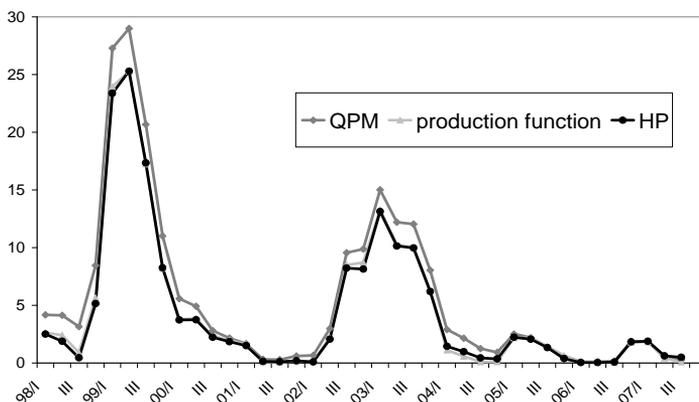
FIGURE 3a Loss function components

FIGURE 3b: Loss Function Values
(3/4 inflation, 1/4 output gap)

Source: CNB, own calculation.

vious conclusion that the most serious problems regarding the fulfillment of inflation targets were concentrated in the years 1998–1999 and 2002–2003. Those periods saw inflation target undershooting as well as negative output gaps at the same time, regardless of the applied output gap estimation technique. On the other hand, in 2000––2001 and 2004–2007, inflation returned closer to the targets as the previous shocks faded, and the economy stabilized close to its potential. *Figure 3b* also shows that if the output gap from the QPM model, determined using the Kalman filter, is applied, the value of the loss function is the highest. This results from the structure of the filter, which – besides the development of GDP – also interprets the evolution of inflation, the low value of which logically implies that the estimated output gap remained in negative values during the period of inflation target undershooting. This estimate of the loss function applied a weight on inflation α of 3/4; nevertheless, calculations of the loss function for other values of the same parameter yield similar conclusions.

4. International Comparisons

The results presented in the previous section can be compared with the conclusions of the available empirical studies analyzing the success rate of inflation targeting on a broader sample of countries. Roger and Stone (2005) discovered that countries which target inflation were outside the target band (±1 percentage point wide) for 43.5 % of the time, i.e., less often than the Czech Republic. In countries characterized by declining inflation targets, i.e., in the course of disinflation, however, the band was missed in 59.7 % of cases, i.e., about as often as in the Czech Republic. However, unlike in the Czech Republic, those deviations from the target were roughly balanced in both directions within the entire sample, and in countries characterized by declining targets they were skewed towards overshooting. The RMSE of the deviations of inflation from the target was 2.2 % for all countries, and 2.7 % for those countries in a process of disinflation, so that the Czech Republic, for its inflation targeting period as a whole, falls approximately in the middle between those two values.

Bulíř et al. (2008) analyzed a sample of countries made up of Chile, the Czech Republic, Hungary, Poland, Thailand, and Sweden. They discovered that those countries were outside the band in 57 % of cases on average, i.e., roughly as often as the Czech Republic. In some countries, target overshooting prevailed (e.g., in Hungary), while some other countries experienced undershooting (the Czech Republic, Poland, and Sweden).

The performance of the CNB, as measured by the frequency with which it missed its target tolerance band as well as the RMSE of the deviations from its inflation targets, is therefore roughly comparable to the results achieved by those countries which applied inflation targeting in order to achieve disinflation. By contrast with this group of countries, however, the average deviation of inflation from the target in the Czech Republic moves in the opposite direction, i.e., in the direction of undershooting, although other such countries can be found as well.

The success rate of inflation targeting on a panel of OECD countries was also analyzed, for example, in (Johnson, 2002), (Ball, Sheridan, 2003), and (Lin, Ye, 2007). Those studies typically compare the development of inflation before and after the introduction of inflation targeting against the development of inflation in those countries where inflation targeting was not introduced. While Johnson (2002) finds evidence for arguments that inflation targeting reduced inflation expectations, Ball and Sheridan (2003) show that the higher drop in inflation in those countries which introduced inflation targeting was mainly due to their higher initial inflation (the issue of "mean-reversion"). Lin and Ye (2007) confirm this hypothesis; moreover, they complement the model with endogenous selection of the monetary policy regime when inflation targeting is opted for by those countries which have been facing higher inflation. The applicability of the above-described approaches to the situation in the Czech Republic and/or in any other countries which applied inflation targeting in order to achieve disinflation, however, is contentious.[17] All of the above-

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[17] A discussion of the success of inflation targeting in countries applying disinflation is given, for example, in (Jonáš, Mishkin, 2003), who cover the Czech Republic, Hungary, and Poland. They also discuss the optimal speed of disinflation in these countries and compare inflation and output performance with other non-inflation targeters in the other CEECs in the period 1998–2002.

-described studies, in fact, exclude from their analyses those countries where the targets decreased in the course of time. The high initial inflation occurring in various transforming economies may have resulted from a number of factors of an administrative nature deserving exemption, such as deregulation or changes in indirect taxes, so "mean-reversion" analyses may bring about different outcomes.

However, this study does not set out to evaluate whether inflation targeting represents a suitable (or superior) instrument for achieving disinflation, or whether inflation targeting was more (or less) successful in the Czech Republic than in other countries. Since the Czech Republic is a small open economy, its inflation reflects global factors to a significant extent. In the following text, therefore, we compare the target fulfillment in the Czech Republic and in some other inflation targeting countries (that is, in economies that are characterized by a similar approach to monetary policy). If we discover any common or similar traits in the deviations of inflation from the target in those countries, such a finding would support the hypothesis that inflation target undershooting occurred with the contribution of global shocks and trends which appeared in other economies besides the Czech Republic.

This analysis focuses on ten economies, in particular: the Czech Republic, Hungary, and Poland (representing Central Europe),[18] the eurozone,[19] Sweden and the United Kingdom (representing the advanced European countries), and Canada and Chile (representing the Americas). This country sample is complemented by New Zealand and Israel. Our selection gave preference to small open economies over large ones (such as Brazil) and also to those economies which maintained trading relations with the Czech Republic; besides "traditional" inflation targeters, we strove to cover those countries which applied inflation targeting for the purposes of achieving disinflation.

Figure 4 shows the deviations of quarterly inflation from the target mid-point for the individual economies since the beginning of 1998. It also depicts the inflation target band in the relevant period.
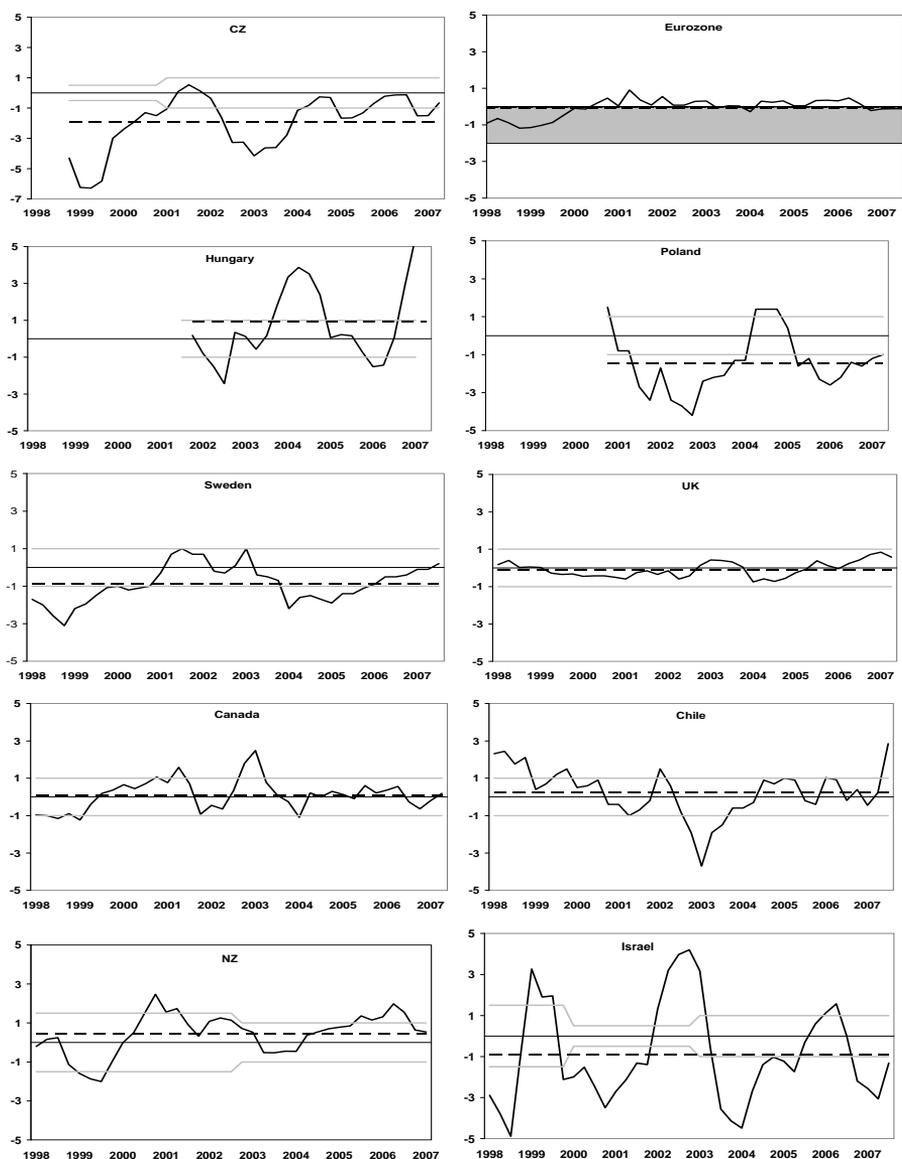
Most economies targeted inflation within a band of ±1 percentage point around their inflation targets; the Czech Republic started with a narrower band of ± 0.5 percentage point, New Zealand, on the contrary, started with a wider band (± 1.5 percentage points) and Israel adjusted its band width twice (first narrowing it from ± 1.5 percentage points to ± 0.5 percentage point, then widening it to ± 1 percentage point). The eurozone applies an asymmetric band by reporting only a ceiling for its definition of price stability (inflation of up to 2 %).[20] The inflation target increased

[18] Unfortunately, we could not include in our analysis the geographically and historically close Slovakia, which did not start explicitly targeting inflation until 2004, when its first target (for the end of 2005) was published. Moreover, Slovakia has experienced over time a shift from a symmetric target to an asymmetric ECB-style target, which – moreover – dropped from up to 2.5 % at the end of 2006 to up to 2 % at the end of 2007 and in 2008. Therefore, the number of comparable observations is very low.

[19] The ECB is typically not considered to be an inflation targeting central bank, because it combines an asymmetric medium-term target for inflation with a target for money supply growth. Still, we decided to include the eurozone in this analysis because it is the most important trading partner of the Czech Republic and – moreover – it reflects the monetary policy relevant to the Czech Republic following its future adoption of the euro.

[20] In 2004, the ECB clarified its definition of price stability in the sense that inflation should fluctuate under, but close to, two percent. In this text, for the sake of simplicity, we considered the value of 2 % to represent also the middle value of the band for the eurozone.

FIGURE 4 Inflation Deviations from the Middle of the Target

within the relevant period only in New Zealand, where the inflation band was adjusted from 0–3 percentage points to 1–3 percentage points. The Czech Republic, Poland, Hungary, and Israel decreased their targets.

TABLE 3 Tests of Symmetric deviations of Inflation from the Target

	CZ	ECB	POL	HUN	SWE	UK	CAN	Chile	NZ	Israel
t-statistics	-6.27	-0.78	-4.78	1.96	-5.39	-1.15	1.25	0.85	2.51	-2.33
p-value	0.00	0.44	0.00	0.06	0.00	0.25	0.40	0.22	0.02	0.03

The targets currently stand either at 2 % (Sweden, the United Kingdom, Canada, New Zealand, Israel, and the eurozone) or at 3 % (the Czech Republic, Hungary, Poland, and Chile). All the economies currently either explicitly or implicitly (the United Kingdom and the Czech Republic) tolerate a band of ± 1 percentage point around the target. Although this band is currently equally wide for all the monitored economies, *Figure 4* shows that in the less advanced economies (the Czech Republic, Hungary, Poland, Chile, and Israel), inflation volatility has been significantly higher, which makes target fulfillment more difficult in the longer run. A first glance at the figure shows that quarterly inflation in the Czech economy in 1998–2007 never exceeded the target band, while inflation appeared more often above the target than under the target in the eurozone. Hungary reported inflation target overshooting, in contrast to Poland, which – together with the Czech Republic – ranks among the most important inflation target undershooters. Inflation in the United Kingdom, as well as in Canada and New Zealand, diverted from the band only in exceptional cases. On the contrary, inflation in Israel and in Chile – due to its high volatility – moved away from the target band relatively often. Among the advanced economies with lower inflation volatility, Sweden reported some asymmetry of the deviations of inflation from the target.

A *t*-test of the symmetry of the deviations of inflation from the targets[21] shows that the Czech Republic, together with Poland, Sweden, and Israel, undershot inflation targets in a statistically significant manner; target overshooting occurred in Hungary and New Zealand (*Table 3*). As far as the ECB, Canada, the United Kingdom, and Chile are concerned, it is not possible to reject the hypothesis of symmetric deviations of inflation from the target.

Table 4 provides some basic statistics on the deviations of inflation from the targets for the individual economies. Six economies experienced a negative average deviation, among them the Czech Republic with the highest absolute value (-1.9 percentage points). The standard deviation is higher – compared to the Czech Republic – only in the cases of Israel and Hungary. The RMSE indicator for the Czech Republic is comparable to the same indicator for the other economies which applied declining targets within the relevant period; however, in comparison to the economies with constant or rising targets, the Czech indicators were worse in general.

Besides assessing the basic descriptive statistics of target fulfillment, it is also important to monitor the empirical statistical distributions of the deviations of inflation from the targets, particularly for those countries that apply declining targets. This

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[21] The test based on *t*-statistics and the presumption of an independent normal distribution (therefore not considering any auto-correlation of the deviations of inflation from the target – a discussion relating to the Czech Republic is given in Section 2 – or any violation of the normality of their distribution – see below in the current section). The higher is the absolute value of the *t*-statistic (and/or the lower is the *p*-value), the higher is the probability of rejecting the null hypothesis of symmetric deviations of inflation from the target.

TABLE 4 Target Fulfillment in the Individual Countries

	Countries with declining target				Countries with constant target						Total	Declining target	Const. target
	CZ	POL	HUN	Israel	Chille	SWE	UK	CAN	ECB	NZ			
No. of observations	36	27	23	39	39	39	38	38	39	37	355	124	231
Average	-1.94	-1.44	0.92	-0.91	0.26	-0.86	-0.08	0.11	-0.06	0.44	-0.36	-0.98	-0.04
Median	-1.50	-1.60	0.17	-1.39	0.40	-1.00	-0.11	0.19	0.04	0.54	-0.22	-1.30	0.02
Standard deviation	1.83	1.57	2.26	2.43	1.31	1.00	0.42	0.83	0.50	1.06	1.62	2.27	0.99
Skewness	-0.98	0.51	0.73	0.57	-0.52	0.03	0.32	0.55	-0.84	-0.59	-0.20	0.50	-0.20
Minimum	-6.29	-4.20	-2.43	-4.88	-3.70	-3.10	-0.75	-1.23	-1.18	-2.01	-6.29	-6.29	-3.70
Maximum	0.54	1.50	5.58	4.21	2.85	1.00	0.84	2.48	0.90	2.48	5.58	5.58	2.85
RMSE	2.50	2.11	2.39	2.57	1.32	1.34	0.42	0.83	0.49	1.12	1.66	2.47	0.99
Relative frequency (in %)													
under target middle	91.4	82.0	30.4	71.8	46.2	82.1	55.3	39.5	41.0	29.7	57.1	71.8	49.1
within band	34.0	15.0	48.0	28.0	67.0	54.0	100.0	78.0	41.0	62.0	54.2	30.6	67.0
outside band	66.0	85.0	52.0	72.0	33.0	46.0	0.0	22.0	59.0	38.0	45.8	69.4	33.0
under band	66.0	70.0	17.0	51.0	10.0	46.0	0.0	11.0	0.0	8.0	26.8	53.2	12.6

FIGURE 5 Histograms of Deviations of Inflation from the Target Mid-point
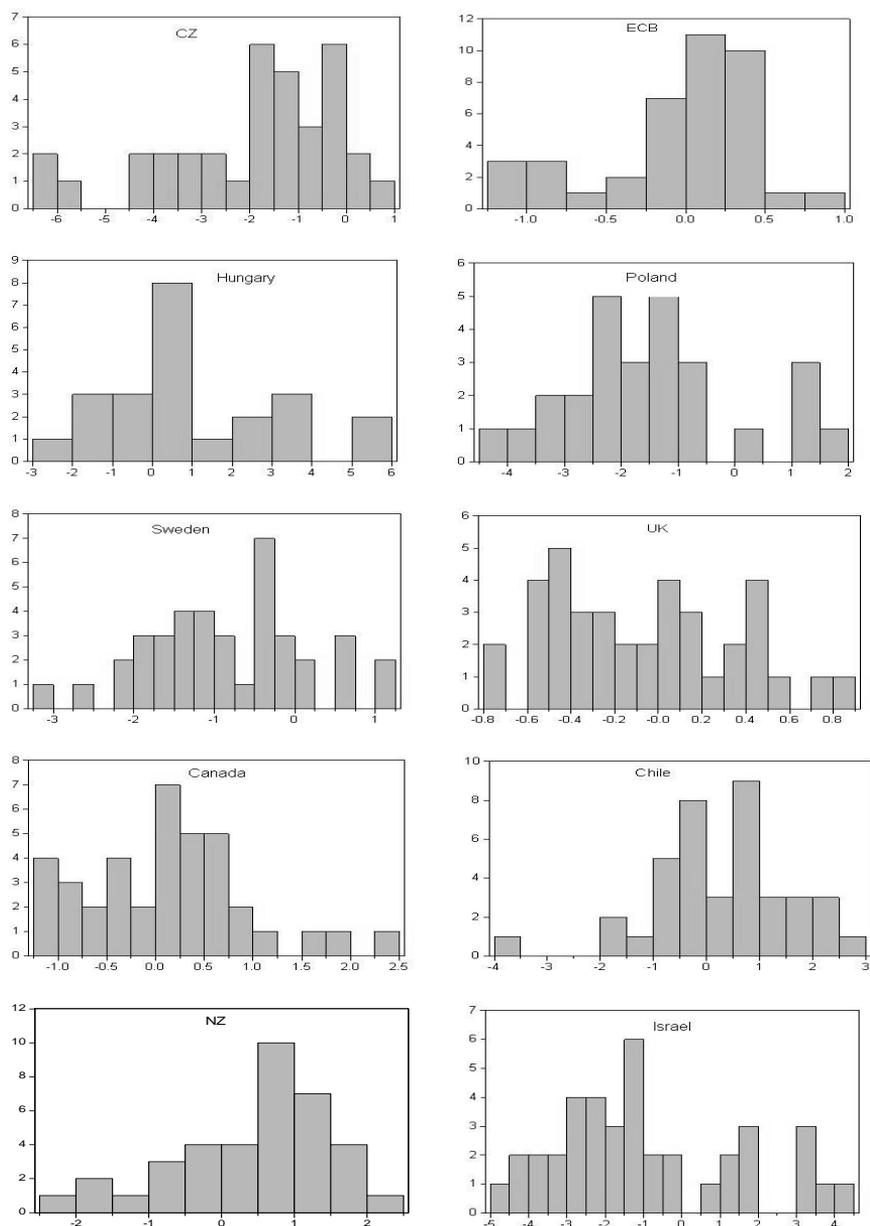
is shown in *Figure 5*, which presents histograms of the deviations of inflation from the target mid-points. The histograms for the Czech Republic, Poland, Hungary, Chile, and Israel show that those countries report significant frequencies also in the more distant intervals of the deviations from the target. It is possible to identify a multi-

peak distribution for them, which indicates that those countries apparently suffered from a number of major shocks over time. Thus, the interpretation of what a symmetric monetary policy means is complicated for the transition economies, due to the importance of such shocks.

The histograms, as well as the skewness statistics[22] in *Table 4*, also show that the presumption of symmetric distribution of the deviations of inflation from the targets has been violated in some of the countries. This fact may affect the results of the standard *t*-tests regarding the symmetry of deviations from the targets (violation of the presumption of normal distribution).

If the empirical distribution function is skewed to the right (i.e., if it has a negative skewness statistic), it can be explained relatively easily in the case of central banks with asymmetrically defined targets, such as the ECB, for which an overshooting of the target is less "pleasant" from the communication point of view than an identical undershooting. This situation may give rise to some asymmetry in monetary policy responses and the monitored asymmetric distribution of the deviations of inflation from the target. It is interesting that the Czech Republic reports a similarly "inclined" distribution function as the ECB. The negative skewness statistic here may be due to implicitly asymmetric monetary policy (that is, the central bank assesses target undershooting as less costly than overshooting, even if its targets are defined as symmetric). A similar outcome can be identified, for example, in New Zealand and partially also in Chile. It is also interesting that all of the other countries that were identified by the *t*-test as significantly undershooting the inflation target either reported relatively symmetric distributions of their deviations of inflation from the target (Sweden) or have this distribution inclined to the other side (Poland and Israel). The asymmetric distribution of the deviations of inflation from the target in these countries may be explained, for example, by the hypothesis that they are worried about cutting interest rates below the level in the reference country. An alternative hypothesis may be based on worries about very low inflation and its negative impact on economic growth. The high asymmetry in the distribution of the deviations of inflation from the target (positive skewness) in Hungary may be explained by the not entirely clean regime of inflation targeting in that country (Hungary, besides inflation, has also targeted the exchange rate in the past and in several cases has preferred to maintain its exchange rate within the fluctuation band rather than to fulfill its inflation targets).

Although the undershooting of the inflation targets in the Czech Republic is to a certain extent specific as regards its distribution function, the target undershooting indicators for the entire group of ten monitored economies (*Figure 6*) show that the developments in the Czech Republic fit well in the international context. The group of monitored countries on average undershot their inflation targets in the years 1998––2007, which is in line with the generally accepted opinion that the past ten years witnessed a major weakening of global inflationary pressures. The periods of the most extensive target undershooting in the Czech Republic (1998–1999 and 2002–2003) also correspond fairly well with the periods characterized by the most ne-

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[22] Positive skewness means that the distribution function is inclined to the left, while negative skewness means that the distribution function is inclined to the right. With symmetric distribution, such as the normal distribution, the skewness is equal to zero.

FIGURE 6 Target Fulfilment Across the Countries (evolution in time)
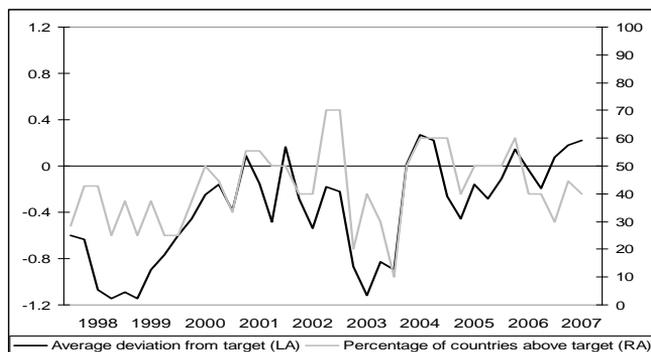
gative deviations of inflation from the targets in the group of economies monitored, as well as with the increased ratio of countries whose inflation was below target in those periods. It seems, therefore, that the Czech Republic, at least to some extent, suffered from global anti-inflationary shocks at these times. Those shocks were multiplied by the specific transformation nature of the Czech economy and the Czech koruna's exchange rate developments.

5. Conclusion

This paper focuses on some stylized facts of inflation target fulfillment in the Czech Republic. The extent of (non-)fulfillment of the target is discussed by comparing the actual course of inflation relative to targets in the various phases of inflation targeting in the Czech Republic. Furthermore, the paper compares the extent of inflation target non-fulfillment in the Czech Republic with the experience of several other inflation targeting countries.

We have found that the challenges related to the achievement of monetary policy goals in the Czech Republic were concentrated into two periods (1998–1999 and 2002–2003), which were characterized by exchange rate appreciation. The exchange rate appreciation periods were very significant, thus the occurrence of two such appreciation episodes within ten years could have caused an inflation target undershooting on average. At the same time, it turns out that no target overshooting took place during the period of exchange rate depreciation and pro-inflationary shocks.[23]

We show that the periods characterized by a strengthening exchange rate were combined with other anti-inflationary factors, some of which were of a global nature. Periods of target undershooting in the Czech Republic indeed correspond to periods of low inflation in the sample of other inflation targeting countries. In particular, the periods of the most extensive target undershooting in the Czech Republic (1998––1999 and (2002–2003) correspond fairly well to the periods characterized by the most frequent occurrence of negative deviations of inflation from the target among the group of economies monitored. It is documented that the CNB's performance is in line with the group of emerging-market inflation targeting central banks regarding the fre-

[23] This conclusion would be modified if we took into account 2008, which has witnessed substantial inflation target overshooting due to a combination of several pro-inflationary shocks.

quency and extent of missing its inflation target tolerance band. However, it is specific (although not unique) in having undershot the target on average, with the empiric distribution of the deviations of inflation from the target being significantly asymmetric.

It is shown that the success rate of target fulfillment changed over the various phases of inflation targeting. By international comparison, the deviations of inflation from the target were very high in the initial phase of inflation targeting. In the following years, the CNB's performance converged to the track record of the relatively successful inflation targeting central banks.

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