I. Introduction

With the growing consensus that price stability should be the overriding long-run goal of monetary policy, many countries have taken active steps to reduce and control inflation. In pursuing the primary monetary policy objective, policymakers opt for one of the basic strategies. The choice for a monetary-policy strategy that has become increasingly popular in recent years is inflation targeting. Also the Czech National Bank Board decided in December 1997 to change its monetary policy strategy and, starting from 1998, switched to inflation targeting. After eight years of relying on intermediate monetary targets and exchange rate peg, this represented an historic change in the strategy of monetary policy. The new CNB strategy however did not mean a change in objective, only in the way in which monetary policy is conducted.

Inflation targeting involves the public announcement of medium-term numerical targets for inflation with a commitment by the monetary authorities to achieve these targets. Implementation of new monetary policy regime is, among other things, subject to the existence of credible tools for forecasting inflation pressures. Required from the CNB not only short-term predictions of inflation, but medium-term predictions as well. This paper focuses on one of the many possible tools used to predict inflation pressures: P* (pronounced as P-Star) model. To this end, a version of the model was developed specifically for the Czech Republic and applied to evaluate the 1991-1999 time series.

II. Inflation Targeting in the Czech Republic

The main monetary policy regimes that central banks have used to control and reduce inflation are a) exchange rate pegging, b) monetary targeting, c) inflation targeting, and d) “just-do-it” strategy. During the past decade a number of small and medium-sized advanced economies have broken with tradition of using intermediate targets such as monetary aggregates or exchange rates and have begun to focus on the inflation rate itself. Inflation targeting is a framework for conducting monetary policy in which policy decisions are guided by expectations of future inflation relative to the announced inflation target.

1 The research has been supported by The Grant Agency of the Czech Republic Project no. GACR 402/00/1166.
2 Mishkin [1997, p. 28]
3 Stern [1999] in one of the most recent studies compares 91 central banks and concludes that the number of countries with inflation targets grew almost seven-fold, from 8 to 54.
Inflation targeting requires two major prerequisites. The first is a degree of independence of monetary policy; the second is the willingness and ability of monetary authorities not to target other indicators. A country that chooses a fixed exchange rate system, for example – which is useful in certain situations – subordinates its monetary policy to the exchange rate objective and will be unable to operate an inflation targeting system, especially when capital can move freely in and out of the country. Having satisfied these two basic requirements, a country can, in theory, conduct a monetary policy centred on inflation targeting. In practice, the authorities also have to take certain preliminary steps. They must establish explicit quantitative targets for inflation for some periods ahead. They must indicate clearly and unambiguously to the public that hitting the inflation target takes precedence over all other objectives of monetary policy. They must set up a model or methodology for inflation forecasting that uses a number of indicators containing information on future inflation. Finally, they must devise a forward-looking operating procedure in which monetary policy instruments are adjusted (in line with the assessment of future inflation) to hit the chosen target. The monetary authorities must have the technical and institutional capacity to model and forecast domestic inflation, know something of the time lag between the adjustment of the monetary instruments and their effect on the inflation rate, and have a well-informed view of relative effectiveness of the various instruments of monetary policy at their disposal.

In its monetary strategy, the CNB has specified the medium-term target of monetary policy for net inflation. To increase the transparency of this key target and to influence inflation expectations, the CNB also announced annual “control” targets. Inflation targets are defined using the concept of net inflation. Net inflation represents the movement of unregulated prices (i.e. the CPI excluding changes in regulated prices) adjusted also for the influence of indirect taxes and abolition of subsidies.

III. Monetary Policy Indicators and Inflation Expectations

An indicator is typically a variable used to predict the future value of another variable. A monetary policy indicator should furnish the central bank with information about whether a given monetary policy approach is likely to meet a specific goal. Moreover, central banks are prone to using not a single indicator but rather sets of indicators. Obviously, in setting inflation targets, where it is necessary to quantify (and forecast) the relationship between the degree of potential failure to meet the inflation target and the required change in the operating monetary policy criterion, the role of an appropriate indicator is extremely important. Generally speaking, parameters of various types can be used as indicators. Values can be monitored that reflect real economic activity (real output or output gap), financial market parameters (financial variables, including the shape and slope of the yield curve), indices...

---

1 Inflation targeting is straightforward, at least in theory. The central bank forecasts the future path of inflation, the forecast is compared with the target inflation rate, the difference between the forecast and the target determines how much monetary policy has to be adjusted. A change in the current policy stance is indicated if projected inflation over a one- to two-year time horizon falls outside announced range. Thus, expected future inflation, as measured by projected inflation, becomes the “intermediate target” (or, more correctly, an indicator variable) for monetary policy.

2 Detailed analyses of experiences with inflation targeting can be found in Leiderman and Svensson [1995] and McCallum [1996], among others.

3 For details, see, among other authors, Šmídková and Hrnčíř [1998].

4 The medium-term target was announced at the end of 1997. This commits the CNB to employing its monetary policy instruments so that net inflation is between 3.5 % and 5.5 % in annual terms at the end of the year 2000. For the end of 2005 the CNB has specified the inflation target at 2% ± 1 percentage point.

5 The CPI at present consists of 754 items, with regulated prices comprising 91 items and net inflation 663 items. The ratio of the two price groups, taking into account their current weights in the consumer basket, is 82:18 in favour of net inflation.
affecting changes in commodity prices and the price of gold and, obviously, monetary aggregates. The use of monetary indicators is also possible in a situation where the relation between monetary aggregates and inflation has become uncertain or unstable and where it would be inappropriate to use such aggregates as intermediary criteria.

As for monetary aggregates and the monetary transmission mechanism, the previous experience had revealed some limitations and weaknesses in the Czech Republic. Hrnčíř and Šmídková [1999] argue, that the links between money supply (M2) and price developments (CPI inflation) as well as between the intermediate target (M2) and controlled interest rates (repo rates) did not prove to be predictable nor sufficiently stable. In addition to the constraints observed elsewhere, the conditions of an economy in transition made their application even less reliable. Consequently, monetary targeting itself could hardly secure a reliable basis for the medium-term disinflation strategy. Inflation targeting, on the other hand, provided a framework integrating a number of relevant economic indicators (including money supply as an important one).

Given the lags in the effect of monetary policy, an inflation target must be forward-looking. Pre-emptive strikes are necessary: action must be taken before the inflation rate begins to rise. Consequently, the central bank’s forecasts of inflation are critical. The authorities should base their monetary policy decisions on a projection for the future path of inflation, although this expectation need not be based on a particular model. In fact, experience in all inflation-targeting countries has shown that using the input from many different models tends to give policymakers the most useful information. A defining feature of inflation targeting is that the target variable, future inflation, is not observed. From an operational point of view, inflation targeting can therefore be seen as a two-steps process, in which the monetary authority must first make an inflation forecast to assess whether, under current policies, inflation is likely to remain within the announced target range. The second step is needed when future inflation is judged likely to move outside the target range. In this instance, a feedback rule that links policy actions to projected inflation is used to determine a path for monetary policy instruments that will bring the projected inflation rate into the target range. Inflation targeting allows the whole range of relevant variables of both the real and fiscal sectors to be integrated into the decision-making process and to setting of monetary policy instruments.

The methodology used to predict inflation during the previous system was not suitable for inflation targeting. The CNB used short-term inflation forecasts (up to one year) based on expert estimation. On the contrary, inflation targeting requires inflation forecasts for a longer period (two to four years). Stavrev [1999] agree that medium- and long-term prediction of inflation is hardly possible without using an appropriate model and call for a macro-model which captures the main characteristic of the transmission mechanism and describes the different channels of monetary policy. CNB started also regular measurement of the inflation expectations of the financial market in May 1999 [CNB, 1999, p. 51]. Using standardised forms, the CNB conducts a monthly survey of predictions for the following selected indicators: a) Year-on-year CPI inflation and net inflation for one- and three- year horizon, b) 1W PRIBOR, 1Y PRIBOR and 5Y IRS for a one-month and one-year horizon, c) the CZK/EUR exchange rate for a one-month and one-year horizon. If all assumptions are

1 A number of criteria underpin inflation forecast. There must be sufficient historical data to estimate reliable relationships, and forecasters must be reasonably confident that these relationships will remain stable under the new regime.
2 Stavrev [1999] presents also a small four equation quarterly macro-econometric model constructed with the aim of predicting net inflation in the Czech Republic.
3 The most liquid segments of the financial market (the interbank deposit market, the interest rate derivatives market, and the foreign exchange market) were selected, taking into account the limitations on the informative power of financial indicators.
accepted, and if we believe that financial markets have some skill at predicting inflation, then these indicators may be of value. An indicator called \( P^* \), which relies on long-term connection between money and inflation, has received not considerable attention at CNB.

**IV. P-Star Indicator for the Czech Republic**

The \( P^* \) indicator offers by far more information and predictive value than monitoring increases in money supply and the rate of monetary aggregates growth. Although some economists view \( P^* \) with a degree of scepticism, it nevertheless attracts substantial interest. Moreover, this statement applies not only to the US, where the original version of this indicator was developed. It also holds for many European countries where it has been employed, including EMU member states. An adjusted and expanded \( P^* \) model was also, among other places, developed and used in Austria.\(^1\) The findings obtained proved the significance of the extent of pegging a domestic currency (here ATS) to a foreign currency (DEM). As there are major reasons to believe that a similar situation will evolve in the Czech Republic, we believe it will be very important to formulate our own, country-specific, version of an expanded \( P^* \) model for the Czech Republic and to try using this model to evaluate past developments in the Czech Republic.

The \( P^* \) inflation model is based on the long-term quantitative theory of money and brings together the long-term determinants of the price level and the short-term changes in current inflation. In essence, it is a response to the question of “what should be the price level as long as the economy evolves towards long-term equilibrium and no other disturbances occur”. The critique of the \( P^* \) model argues that \( P^* \) approach does not address the central question of causality. Hall and Milne [1994] also argue, that the \( P^* \) relationship does not have a causal link with prices but rather the causality runs from prices to money.\(^2\) Since relevant literature already has more or less accurate descriptions of the model,\(^3\) the \( P^* \) model can be introduced here using a simple example.\(^4\) If follows from the above example that the substance of the \( P^* \) model is the identification of the long-term equilibrium price level as a variable determined by current money supply, potential income and the equilibrium rate of money circulation. This identification is then followed by evaluation of a reduced form of short-term changes in inflation that fill the price gap, leading the actual price level to the equilibrium price level \( P^* \).

Initially designed for a large and relatively closed US economy using a floating exchange rate, in the early 1990s the original \( P^* \) model was adjusted to accommodate small open economies with a fixed exchange rate. In the latter example, the assumption is that a large foreign economy formulates its monetary policy in a relatively autonomous fashion

---

\(^1\) The idea was to find out to what extent Austria’s inflation was influenced by monetary policy pursued in the EU or Germany, since in countries with pegged exchange rates changes in domestic prices are to a large extent determined by monetary conditions in the “anchor” country or countries, here in Germany.

\(^2\) Hall and Milne [1994] find that there is some causality running from money to real income, so that monetary conditions do seem to have some predictive power for future levels of activity. They have proposed a new concept of causality, which is less stringent than Granger causality and which focuses on the long run.

\(^3\) In the Czech Republic, see e.g. Frait and Kulhánek [1996], Frait [1997], Kulhánek [1997], Frait, Komárek and Kulhánek [1998].

\(^4\) The change equation suggests that the price level \((P)\) equals to the money supply \((M)\) per real income unit \((Y)\) times velocity of money circulation \((V)\). In the long run real income equals to potential real income \((Y^*)\) and equilibrium velocity \((V^*)\) is independent from money supply or from potential real income. Assuming that current M2 is CZK 600 bil. and the velocity of money is 1.65, long-term spending would, in accordance with the change equation, be equal 600 x 1.65, i.e. CZK 990 bil. To arrive at long-term price equilibrium \( P^* \), this long-term spending should be divided by the economy’s potential output. If this output is projected at CZK 820 bil. (in constant prices), the long-term price level will be \( P^* = 990/820 = 1.21 \). Now, we must compare the long-term equilibrium price level \( P^* \) with the current price level \( P \). If, for example, the current price level is 1.25, then the long-term equilibrium price level is lower than the current level and, unless disturbances evolve in the economy, future price levels should tend to decline. Thus, to preserve price stability, monetary policy moderateness could be recommended. An opposite situation would warrant expectations of rising prices.
irrespective of the goals pursued by small economies and thus serves as a system anchor for a small open economy. In formulating a P* model for the Czech Republic, the notion was used of a weighted price gap as a point of departure that assumed an implicit or explicit future peg of the national currency to DEM or Euro as a reflection of substantial dependence of economic policy on the economic policies of EMU member states.

We identified two price gaps and we proceed with the estimates of the inflation dynamics response to both the gaps. The first price gap is represented by the domestic price gap (GAPD) defined as a difference between the velocity of money circulation gap (v - v*) and real income gap (y - y*). The scalable variable Y was chosen to be not gross domestic product but domestic aggregate expenditures, which include imports. Using domestic aggregate expenditures instead of GDP means that, in the short term, an excess in money supply does not only lead to an increased nominal income but also to rising imports. In structuring the domestic price gap, the quarterly consumer prices index was used as well as nominal and real domestic expenditures, M2 and circulation velocity V2 during IVQ/1991 to IQ/1999. Seasonal variables were adjusted using the multiple sliding averages method. The second price gap used in the model was the foreign price gap (GAPF). The gap is given by a difference between the actual price level (p) and equilibrium price level (pDF*) determined abroad (in Germany) via changes in net foreign assets in the domestic monetary base, which are linked to the explicit or implicit peg of CZK to DEM. A positive gap should again lead to deceleration and a negative gap to acceleration of inflation. In computing foreign price gap data were used on changes in the Czech CPI (P), Germany’s nominal and real GDP, aggregate M3G, velocity of its circulation V3G as well as the nominal and real CZK/DEM exchange rate.

With regard to the attributes of the time series used, ADF tests proved that their logarithms were not stationary, while their first differentials were stationary. The calculated values of domestic and foreign price gaps were stationary.

The second step in the application is to estimate the response of inflation dynamics to the price gaps. Based on the above defines properties, the P* model was estimated for changes in the inflation rate \( \Delta \pi_t \) as a reduced form of the error correction model in the following format:

\[
\Delta \pi_t = a_0 + a_1 (GAPD)_{t-1} + \sum_{j=1}^{4} a_j \Delta \pi_{t-j} \\
\Delta \pi_t = b_0 + b_1 (GAPF)_{t-1} + \sum_{j=1}^{4} b_j \Delta \pi_{t-j} \\
\Delta \pi_t = c_0 + c_1 (GAPD)_{t-1} + c_2 (GAPF)_{t-1} + \sum_{j=1}^{4} c_j \Delta \pi_{t-j}
\]  

1 Each small economy views the monetary policy of the anchor country as given and meticulously complies with the pegging requirement. In a situation like this one the fixed peg to the anchor economy determines the equilibrium price level of the small economy \((P^D*)\) as follows: \( P^D* = E \cdot P^F*/R* \), where \( E \) is the fixed nominal and \( R* \) the real equilibrium exchange rate and \( P^F* \) is the equilibrium price level of the large foreign economy.

2 However, contrary to the original definition, these were reversed, which means that they were not calculated as \((p^*-p)\) but rather as \((p-p^*)\).

3 Domestic price gap was calculated using the equation: \( GAPD = (p - p^*) = \frac{v - v^*}{y - y^*} \) (1), where \( y \) is actual income, \( y^* \) equilibrium real income, \( v \) actual and \( v^* \) equilibrium money circulation velocity. All variables are expressed as logarithms.

4 The velocity of money circulation \( V \) is not measured as income but as expenditure velocity. As a result, velocity does not diminish like income velocity but increases instead.

5 The foreign price gap \( GAPF \) was calculated using the following equation:

\[ GAPF = (p - p^F*) = [(p - (p^F + e + r*)'] = [(p) - (m3G + v3G - yG + e + r*)] \]  

where \( p^F* \) is the equilibrium price level determined abroad, \( p^F \) is equilibrium foreign price level, \( e \) is nominal and \( r* \) is real equilibrium exchange rate.

6 The equilibrium values of the respective time series \((y, v2, r, yG, and v3G)\) were, because of their non-stationary nature, obtained using the Hodrick and Prescott filter.
The coefficients of the two price gaps should be negative because a positive price gap \((p-p^*)\) in a previous period should subsequently be reflected in reduced inflation pressures. Delayed inflation change coefficients should also be negative. Table 1 presents estimates of the above \(P^*\) model for the Czech Republic during IVQ/1991 to IQ/1999. A small number of observations notwithstanding, the results have been surprisingly encouraging. Given the statistical significance of a negative coefficient and price gaps, the above model should not be rejected. Moreover, connecting the two price gaps enhances the predictive value of the model. The negative coefficients of the price gaps and delayed inflation rates as well as their consistent decline suggests that the model indeed revert to equilibrium. Equation (5b) can be considered a representative estimate.

### Table 1: Estimates of P-Star model equations for the Czech Republic

<table>
<thead>
<tr>
<th></th>
<th>GAP(_{t-1})</th>
<th>GAP(_{t-1})</th>
<th>(\Delta \pi_{t-1})</th>
<th>(\Delta \pi_{t-2})</th>
<th>(\Delta \pi_{t-3})</th>
<th>(\Delta \pi_{t-4})</th>
<th>dummy</th>
<th>R(^2)adj</th>
<th>S.E.R.</th>
<th>D.W.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a.</td>
<td>-0.16 (-1.61)</td>
<td>xxx</td>
<td>-0.75 (-3.69)*</td>
<td>-0.39 (-1.63)</td>
<td>-0.41 (-1.70)</td>
<td>-0.23 (-1.15)</td>
<td>xxx</td>
<td>0.43</td>
<td>2.29</td>
<td>1.69</td>
</tr>
<tr>
<td>3b.</td>
<td>-0.12 (-1.34)</td>
<td>xxx</td>
<td>-0.73 (-3.91)*</td>
<td>-0.38 (-1.74)***</td>
<td>-0.41 (-1.87)***</td>
<td>-0.18 (-0.96)</td>
<td>2.18</td>
<td>2.11</td>
<td>1.32</td>
<td></td>
</tr>
<tr>
<td>4a.</td>
<td>xxx</td>
<td>-0.43 (-5.04)*</td>
<td>-0.71 (-4.49)*</td>
<td>-0.34 (-2.03)***</td>
<td>-0.33 (-1.97)***</td>
<td>-0.14 (-0.99)</td>
<td>xxx</td>
<td>0.70</td>
<td>1.65</td>
<td>2.22</td>
</tr>
<tr>
<td>4b.</td>
<td>xxx</td>
<td>-0.41 (-5.44)*</td>
<td>-0.71 (-5.79)*</td>
<td>-0.35 (-2.41)***</td>
<td>-0.35 (-2.42)***</td>
<td>-0.11 (-0.89)</td>
<td>1.94</td>
<td>0.79</td>
<td>1.41</td>
<td>1.97</td>
</tr>
<tr>
<td>5a.</td>
<td>-0.19 (-3.15)*</td>
<td>-0.45 (-6.22)</td>
<td>-0.81 (-6.54)*</td>
<td>-0.44 (-3.04)</td>
<td>-0.41 (-2.83)***</td>
<td>-0.22 (-1.81)***</td>
<td>xxx</td>
<td>0.80</td>
<td>1.39</td>
<td>2.02</td>
</tr>
<tr>
<td>5b.</td>
<td>-0.16 (-3.07)*</td>
<td>-0.43 (-6.73)*</td>
<td>-0.79 (-7.43)*</td>
<td>-0.43 (-3.47)</td>
<td>-0.41 (-3.32)</td>
<td>-0.18 (-1.73)***</td>
<td>1.61</td>
<td>0.86</td>
<td>1.19</td>
<td>1.93</td>
</tr>
</tbody>
</table>

The estimation method was OLS; the dependent variable was the quarterly non-annualised inflation rate expressed in %, * 1% significance, ** 5% significance, *** 10% significance; numbers in brackets represent t-factor statistics.

### V. Conclusions

The \(P^*\) model of inflation customised for the Czech Republic could be used as one of many inflation pressures indicator within the inflation targeting regime, which the Czech National Bank is employing in its current monetary policy. The foreign price gap could also act as a warning signal of potential inflation threat that is often overlooked. Based on the estimates conducted using the model,\(^2\) one could, albeit with a caution, arrive at the following conclusions: Above all we claim that inflation dynamics in the Czech Republic follows the premises of \(P^*\) model: (a) current inflation tends to close the price gap from the previous period, i.e. the difference between actual and equilibrium prices, (b) the price level only slowly adjusts to the long-term equilibrium; in the short run, therefore, money supply may significantly influence economic activity in the Czech Republic, (c) the foreign component of the price gap seems to be more relevant for this than the domestic one. The results also confirm the hypotheses that equilibrium price level in the Czech Republic is significantly affected by the German- and EMU- monetary policy.

\(^1\) The result can be interpreted to indicate that a positive 1% domestic price gap brings about a 0.16% reduction in the inflation rate during the next quarter, whereas a positive foreign price gap of 1% results in a 0.43% reduction in the inflation rate. Thus, in the Czech Republic the foreign price gap appears to play a more important role than the domestic one, which is consistent with the theoretical assumptions of the model, since the peg of the CZK exchange to the DEM was fairly strong during the period and is likely to remain so.

\(^2\) For details see [Kulhánek and Frait, 1998], [Frait, Komárek and Kulhánek, 1998].
References


