

# **P-STAR-MODEL BASED ANALYSIS OF INFLATION DYNAMICS IN THE CZECH REPUBLIC**

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## **Abstract**

The paper presents a version of the P\* model of inflation dynamics for a small open economy and applies it to the Czech economy time series from the period of 1991-1999. The paper is organised as follows. Section 2 presents a brief discussion of the monetary policy indicators issue. Section 3 describes the logics of the P\* model. Section 4 explains the extension of the basic model to the case of a small open economy. Section 5 applies the model to the Czech economy data and presents the estimates of the Czech inflation dynamics determination.

The results of the estimates suggest that the dynamics of the Czech inflation evolves in line with a P\* model logic: the inflation in the current period changes to close the price gap, i.e. the gap between actual and equilibrium price level. The foreign component of the price gap seems to be more important than domestic component which supports the hypothesis that the equilibrium price level in the Czech Republic is to a large extent determined by the monetary policy in the EU via the explicit or implicit peg of the Czech currency exchange rate to EUR. The overall results show that the inflation in the Czech Republic is primarily a monetary phenomenon.

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## 1. Introduction

In the 1990s, some of the central banks changed their previous monetary policy procedures. They have relinquished explicit goals based on targeting particular money supply aggregate and its utilisation as an intermediate target of monetary policy. A major, if not the crucial, reason for this change was the fact that in many advanced economies the velocity of money circulation frequently and dramatically fluctuated, thus eliminating the stable relationship between money supply and inflation and between money supply and income.

The Czech National Bank, which initially relied on the M2 target, also switched to a new monetary policy strategy. Since 1998 its monetary policy had been based on publicly announced inflation target.<sup>1</sup> The use of this new monetary policy strategy is, among other things, subject to the existence of credible tools for forecasting inflation pressures.

This paper focuses on one of the many possible tools used to predict inflation pressures – P\* inflation model (P-Star model). This is a relatively simple model of inflation dynamics that enables forecasting short-run inflation changes as a process in which actual price level adjusts to the equilibrium price level determined in line with the quantity theory of money. With this goal in mind, a version of the P\* model was developed specifically for the Czech Republic and applied to evaluate the 1991-1999 time series.

## 2. Monetary Policy Indicators

Monetary policy strategy based on direct inflation targets shares only single quantified medium-term and long-term inflation target, be it in the form of percentage points or a band several percentage points wide, and operates without the intermediate target of the money supply growth rate. Monetary policy decisions by the central bank thus reflect expected inflation rate with a respect to the announced inflation target. However, the changes in the inflation rate significantly lag behind changes in monetary policy; in developed economies this lag is estimated at as much as two years. For this reason, not only can the success of monetary policy be ascertained after a relatively long period, but such evaluation is subject to the availability of an appropriate indicator, or a set of indicators, filling a substantial gap between operating targets and other values employed in the transmission mechanism of monetary policy.

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, variables of various types can be used as indicators. These are indicators of real economic activity (real output or output gap), financial market indicators (financial variables, including the shape and slope of the yield curve), indices measuring changes in commodity prices and the price of gold and, obviously, monetary aggregates. The use of monetary indicators is also

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<sup>1</sup> In March 1990, New Zealand was the first to introduce direct inflation targeting by the central bank. The move was followed by central banks in Canada (February 1991), the UK (October 1992), Sweden (January 1993), Finland (February 1993), Australia (in 1993), and Spain (November 1994).

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 targets.

The P\* (P-Star) indicator offers by far more information and predictive power than monitoring increments in money supply and the rate of monetary supply growth. Although some economists view P\* with a degree of scepticism, it nevertheless attracts substantial interest. Moreover, this statement applies not only to the U.S.A., where the original version of this indicator was developed.<sup>2</sup> It also holds for many European countries where it has been employed,<sup>3</sup> including EU member states.<sup>4</sup> An augmented P\* model was also, among other places, developed and used in Austria. 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.<sup>5</sup> 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.

### 3. Logics of the P\* Model

The P\* inflation model is based on the long-term quantitative theory of money and puts together the long-term determinants of the price level and the short-term changes in current inflation. In general, 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."

It follows from the above example that the substance of the P\* model is the identification of the long-run 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 P to the equilibrium price level P\*.

The price gap, which is the focus of analysis and which suggests future changes in inflation, is constructed by the combination of the quantity equation and the long-run price level equation:

$$P = MV/Y \quad (1)$$

$$P^* = MV^*/Y^* \quad (2)$$

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<sup>2</sup> The initial version of the P\* model was endorsed by Federal Reserve Boards of Governors [Hallman, Porter and Small 1991]. It was intensively developed by several other federal banks of the Federal Reserve System.

<sup>3</sup> Most existing empirical applications support the P\* model. Examples of extensive relevant literature include [Tatom 1990], [Hoeller and Poret 1991], and [Tödter and Reimers, 1994]. Compared to small economies, however, the results are generally much better in large economies. This is apparently due to the fact that the major determinants of the price level in a country are the exchange rate arrangement, the size of the economy and its openness.

<sup>4</sup> Hoeller and Poret [1991], for example, applied the P\* model to OECD countries and to price changes in EMS countries; Fels and Mayer [1995] used the model to evaluate price changes in Germany, France and The Netherlands and in the "monetary union" encompassing these countries; Wesche [1998] estimated the model in respect of price changes in the EU and in the future Euro zone.

<sup>5</sup> Groeneveld [1995].

Thus, one can write:

$$GAP = P^*/P = Y/Y^* \cdot V^*/V \quad (3),$$

or, in logarithmic form that is commonly used here, the equation will be:<sup>6</sup>

$$GAP = p^* - p = (y - y^*) + (v^* - v) \quad (4).$$

It can be derived from the above relation that the price gap ( $p^* - p$ ) represents a combination of two other gaps – capacity utilisation gap ( $y - y^*$ ) and liquidity gap ( $v^* - v$ ). The price level gap therefore indicates inflation pressures in the economy as long as the extent of production capacity utilisation is too high and/or there is a monetary overhang, where the velocity of money circulation is below, and liquidity holding above, their respective long-run equilibrium.<sup>7</sup>

It is this very fact that is the main advantage of  $P^*$  versus traditional inflationary pressures indicators, which only take into account either the output gap or liquidity gap. In the  $P^*$  model the price gap takes account of both real factors (measured by the real income gap) and the monetary factors of inflationary pressures (measured by the velocity gap). Theoretically, the price gap is equal to zero after economic adjustment and the price level  $P$  are adjusted to equate the equilibrium price level  $P^*$ , i.e. the price level that would be achieved if, at the given extent of money balances, provided output and velocity were retained at their equilibrium. When real income and velocity stay at the equilibrium levels, price level moves together with money supply and inflation is a monetary phenomenon.

Other advantages of the proposed approach consist of the theoretical base and relative simplicity. Moreover, used as a monetary policy guideline, this approach also imposes a degree of discipline on the central bank as it indicates that the accumulated effects of monetary policy on money supply are ultimately reflected in the price level. This suggests that, in a situation when the economy does not fully utilise available capacity, an increase in money supply will influence prices and future inflation.<sup>8</sup>

Generally speaking, the  $P^*$  model can be simplified and reduced to the inflation equation, in which the inflation rate at period  $t$  is a function of the price gap during the previous period  $GAP_{t-1}$  and of the inflation rate during the previous period  $\pi_{t-1}$ :<sup>9</sup>

$$\pi_t = \alpha (GAP_{t-1}) + \pi_{t-1} \quad (5a),$$

$$\pi_t = \alpha (p^*_{t-1} - p_{t-1}) + \pi_{t-1} \quad (5b).$$

As long as the actual inflation rate  $\pi_t$  is not stationary, the above equations are prone to the danger of spurious regression. In that case one should work with changes in the inflation rate ( $\Delta \pi_t$ ) and

<sup>6</sup> Small characters signify natural logarithms.

<sup>7</sup> As long as excessive increases in the money supply during a given period are not reflected in current prices, economic subjects review their holdings of real money balances and the velocity of money circulation is reduced below long-run levels because real income exceeds potential income and because velocity is reduced and income increases. This generates inflationary pressures in the economy until demand for money and interest rates adjust to the increased money supply and until the labour market adjusts to the money illusion. Only then will velocity, real income and price levels revert to their equilibrium levels.

<sup>8</sup> The danger of stabilisation policy conducted to stabilise real economy is that the price level is then determined as a by-product of monetary policy. By contrast, the  $P^*$  model, on the one hand, emphasises the long-run substance of price level determination and, on the other hand, offers a framework for evaluating and monitoring short-run stabilisation interventions in terms of their consistency with long-term inflation targets.

<sup>9</sup> Lagged inflation is added to the equation to better reflect short-term changes.

equation (3) should be transformed into the difference form by moving  $\pi_{t-1}$  to the left-hand side and adding the inflation lags of the previous period ( $\pi_{t-1}$ ) to capture the inflation dynamics:

$$\pi_t = \alpha(p_{t-1}^* - p_{t-1}) + \beta\pi_{t-1} \quad (6).$$

This basic equation may, and in practice does, include lagged values of inflation changes, the absolute values of lagged inflation or various temporary factors that influence prices, such as changes in energy prices or in administered prices.

#### 4. Applying the P\* Model to a Small Open Economy

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.<sup>10</sup> In the latter example, the assumption is that a large foreign economy, e.g. Germany, manages its monetary policy in a relatively autonomous fashion irrespective of the goals pursued by small economies and thus serves as a system anchor for a small open economy, such as the Czech Republic. The large economy is not influenced by the policies pursued by the small economy; by contrast, each small economy views the monetary policy of the anchor country as given and strictly sticks to the obligation to peg the exchange rate. In a situation like this the exchange rate peg determines the equilibrium price level of the small economy ( $P^{D*}$ ) as follows:

$$P^{D*} = E \cdot P^{F*} / R^* \quad (7),$$

where E is the fixed nominal and  $R^*$  the real equilibrium exchange rate,  $P^{D*}$  is the equilibrium price level of the small economy and  $P^{F*}$  is the equilibrium price level of the large foreign economy.

Subsequently, we cannot confine ourselves to the original definition of P\* and GAP for a closed economy but should rather deal with the long-term equilibrium price level of a small open economy determined by an exchange rate pegged to a foreign currency ( $P^{D*}$ ). The domestic price level being defined in this way, the domestic money market equilibrium of a small economy should be maintained by adjusting the domestic money supply.

With regard to short-term price changes in small economies with pegged exchange rates, the outlined approach has several implications. When designing a P\* model for the Czech economy, one should take into account the fact that the price level determined abroad should, by means of exchange rate limitations, influence domestic inflation. Therefore, it can be used to define the foreign, or foreign-determined, price gap ( $GAP^F$ ). A possible definition would be:

$$GAP^F = (p^{D*} - p^D) \quad (8a),$$

which, after using (7), would be:

$$GAP^F = [(p^{F*} + e - \ln R^*) - p^D] \quad (8b).$$

If the current domestic price level  $P^D$  exceeds the foreign-determined equilibrium price level  $P^{D*}$ , pressure will be exerted to reduce domestic inflation<sup>11</sup> and vice versa.

Furthermore, it is necessary to consider the fact that the domestic price gap, hereinafter-designated  $GAP^D$ , would lose its significance with a strictly fixed exchange rate as the domestic money supply becomes endogenous, i.e. beyond central bank control. However, it follows from literature on sterilisation and offsetting capital flows that a small open economy may, to a certain

<sup>10</sup> Above all, see Kool and Tatom [1994].

<sup>11</sup> The extent of pressure on domestic inflation and the rate of adjustment to an equilibrium depend on the rate of arbitrage on commodity and capital markets and on the extent of economic integration.

degree, retain its autonomy in determining short-run and medium-run money supply as the capital mobility is restricted. Under this realistic scenario, GAP is a weighted price gap, which is a weighted average of the domestic price gap  $GAP^D$  and of the foreign-determined price gap  $GAP^F$ :

$$GAP = (1 - w) (p^* - p^D) + w (p^{D*} - p^D) \quad (9).$$

As an indicator of future price movements, the advantage of the weighted price gap is that it not only takes into consideration real factors as measured by the velocity gap, but also external factors as measured by the foreign-determined component of the price gap.

### 5. $P^*$ model for the Czech Republic

In this section we define and estimate a  $P^*$  model for the Czech economy. To do this, we calculate first two price gaps which are inverted with respect to the original definition, i.e. they are calculated as  $(P - P^*)$ , as is common in the empirical  $P^*$  model literature. We proceed with the estimates of the inflation dynamics response to both the price gaps.

The first price gap is represented by the domestic price gap ( $GAP^D$ ) defined as a difference between the velocity of money circulation gap ( $v - v^*$ ) and real income gap ( $y - y^*$ ):

$$GAP^D_t = p_t - p^*_t = (v_t - v^*_t) - (y_t - y^*_t) \quad (10),$$

where  $p$  is actual price level,  $p^*$  is equilibrium price level,  $y$  is actual real income,  $y^*$  is equilibrium real income,  $v$  is actual velocity, and  $v^*$  is equilibrium velocity<sup>12</sup>. A positive gap should lead to deceleration and a negative to acceleration of inflation (a negative coefficient should emerge from the regression estimates).

The important aspect of our approach is that the scale variable of domestic money demand ( $Y$ ) was chosen to be not gross domestic product but domestic aggregate expenditures, which include imports. Using domestic aggregate expenditures instead of gross domestic product means that, in the short-run, an excess in money supply does not only lead to an increased nominal income but also to rising imports. The velocity of money circulation  $V$  is thus not measured as income velocity but as expenditure velocity. As a consequence, the velocity does not exhibit a fast declining trend that was a key justification (or excuse) for the excessive money supply growth during 1994 to 1996 period.

In computing the domestic price gap, the quarterly consumer prices index<sup>13</sup> was used as well as nominal and real domestic expenditures, M2 aggregate and its velocity  $V2$  during IVQ/1991 to IQ/1999. Variables, which exhibited seasonality, were adjusted using the multiplicative MA method.

The second price gap used in the model was the foreign price gap ( $GAP^F$ ). The gap is given by a difference between the actual price level ( $p$ ) and equilibrium price level ( $p^{DF*}$ ) determined „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. The foreign price gap  $GAP^F$  was calculated using the following equation:

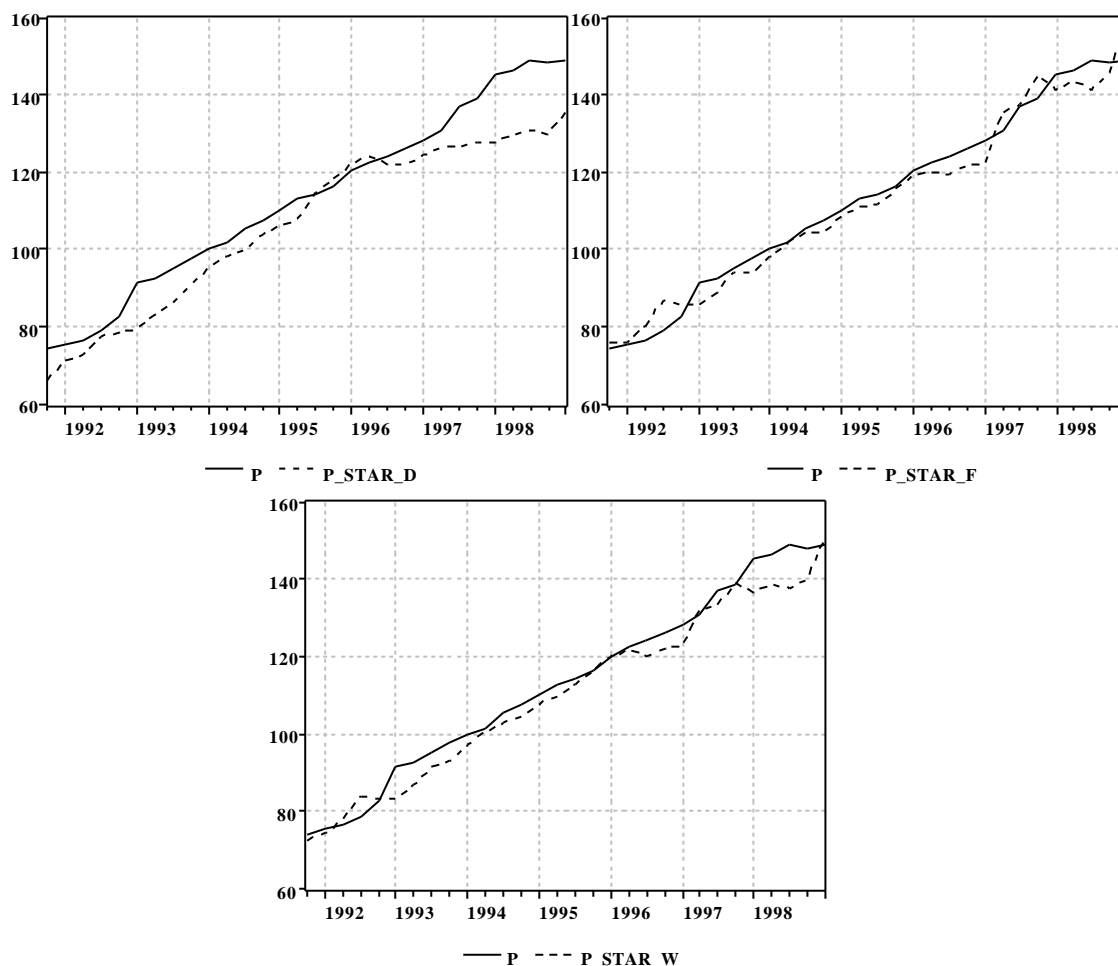
$$\begin{aligned} GAP^F_t = (p_t - p^{DF*}_t) &= [(p_t) - (p^{F*}_t + e_t - r^*_t)] = \\ &= [(p_t) - (m3^G_t + v3^*G_t - y^*G_t + e_t - r^*_t)] \end{aligned} \quad (11),$$

<sup>12</sup> Again, all variables are expressed as logarithms.

<sup>13</sup> The choice of a price index appears to be a significant challenge. A quarterly deflator obtained by dividing nominal and real incomes or expenditures seems to be suspect due to its low correlation with quarterly CPI inflation and it appears to be seasonal too. We thus preferred to use the CPI and this is also used when recalculating the real expenditures to the nominal figures in connection with velocity calculations. Experiments during final inflation dynamics equation estimation persuaded us that it is not very important what type of a price deflator is used for the velocity calculation.

where  $p^{DF*}$  is the equilibrium price level determined abroad,  $p^{F*}$  is equilibrium foreign, i.e. German, price level,  $e$  is nominal exchange rate, and  $r^*$  is equilibrium real exchange rate. A positive gap should again lead to deceleration and a negative to acceleration of inflation (a negative coefficient should emerge from the regression estimates).

FIGURE 1 Actual versus domestic equilibrium and actual versus foreign equilibrium price levels



In computing foreign price gap, data were used on changes in the Czech consumer price index  $P$ , Germany's nominal and real gross domestic product  $Y^G$ , Germany's monetary aggregate  $M3_G$ , velocity of its circulation  $V3_G$  as well as the nominal and real CZK/DEM exchange rate calculated with the use of the Czech and German consumer price indices. With regard to the characteristics of the time series used ( $y$ ,  $v2$ ,  $e$ ,  $r$ ,  $y_G$ ,  $v3_G$ ,  $p$ ), ADF tests proved that their levels were not stationary, while their first differences were stationary. Because of their non-stationary nature, the equilibrium values of the respective time series ( $y$ ,  $v2$ ,  $r$ ,  $y_G$ ,  $v3_G$ ) were obtained using the Hodrick-Prescott filter<sup>14</sup>. The calculated values of domestic and foreign price gaps were stationary.

<sup>14</sup> The approximation of the equilibrium levels using stochastic trends is, of course, not without problems since it may lead to biased estimates. This technique has, however, become very popular among empirical economists recently and it has been proven that the estimated trends are in many cases a satisfying approximation to the equilibrium development. We believe we get the relevant trend component by filtering domestic expenditures, even though we understand that we do not obtain true „potential“ GDP estimates. We reckon that the use of filtering may bare some problems but due to the available database it is the only possible way to do so. If the model were to be used for estimates of out of sample future inflation pressures, the HP filter would then need to

FIGURE 2 Domestic and foreign price gap (%)

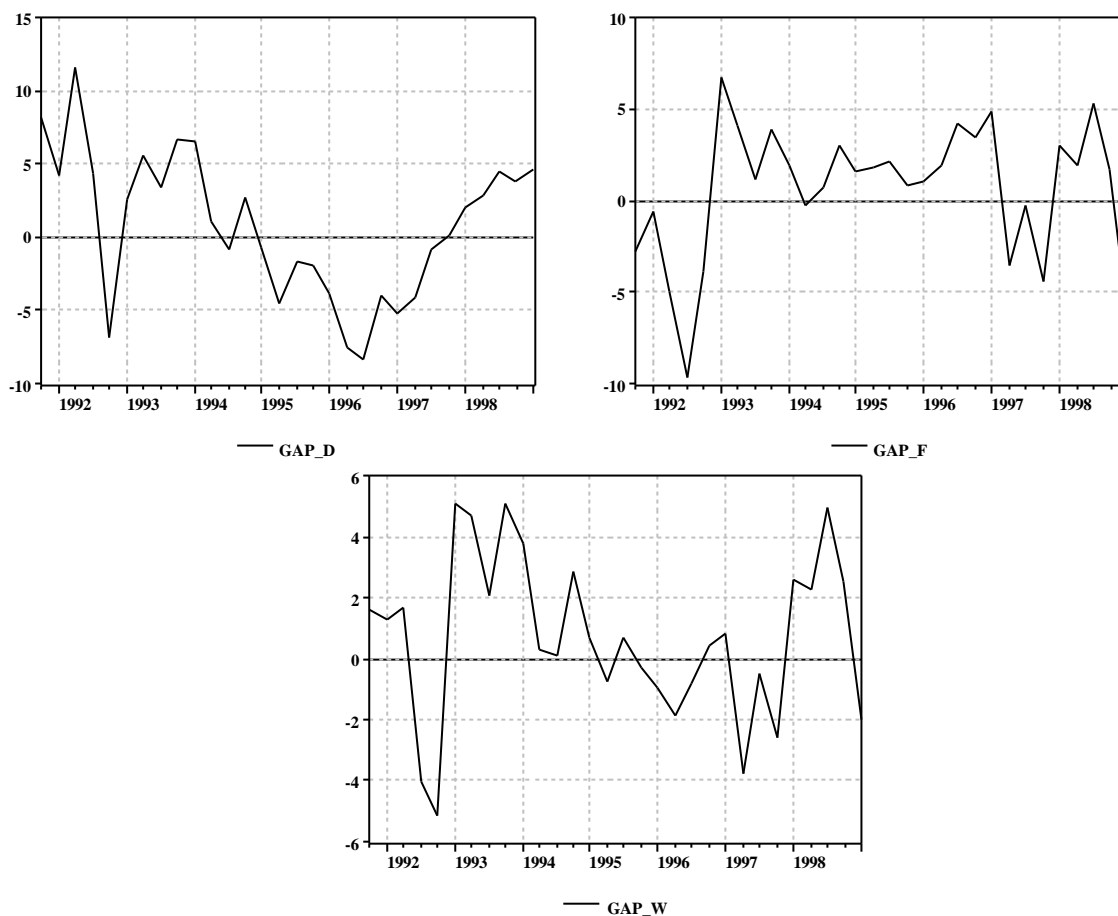


Figure 1 compares the development of the actual price level with the estimated equilibrium price levels. It is apparent that the developments of the domestic and foreign component of equilibrium price level are contradictory. Domestic  $P$  is above the  $P^*$  which points to the future inflation drop while the foreign  $P$  is below the  $P^*$  which then shows an expected inflation hike. This is reflected in the values of price gaps depicted in Figure 2. The weighted value of the variables is shown in the lower parts of both figures. From the econometric estimates shown below it appears that the foreign price gap is more significant for future inflation development and its weight is thus higher in the figures (60 %) that the weight of domestic price gap (40 %). One, however, needs to work with this ration very carefully since it is impossible to get a precise idea about its value and it may also change in time. Both weighted figures nevertheless show that the price level was close to the equilibrium in the end of the first 1999-quarter while there are only minor inflation pressures indicated in the next quarters.

As pointed out, Figures 1 and 2 show that the domestic gap indicated an inflation deceleration in the end of the first quarter while the foreign gap indicated inflation acceleration. Here we get to a weak point of our approach: unless we have a reasonable estimate of inflation dynamics, both gaps may indicate contradictory trends. The second step in the application is thus to estimate the response of inflation dynamics to the price gaps. Prior to estimating equations for dynamics in quarterly inflation, it was necessary to decide whether the estimations should focus on the inflation rate or on

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be replaced by an alternative technique.



the changes in the inflation rate, which is more common. Although it might be possible to estimate the inflation rate equation<sup>15</sup>, it is more appropriate, because of lower statistical significance of the former, to estimate the equation for changes in the inflation rate. In making estimates, we also added a dummy variable (0, 1) to capture significant fluctuations of the price level resulting from adjustments of taxes and administered prices. It follows from Table 1 that this dummy variable does enhance significance of the estimates. Unfortunately, it renders the obtained coefficients less usable for forecasting purposes. However, given the importance of changes in administered prices for Czech quarterly inflation during the period in question, it is hardly possible to use an alternative approach<sup>16</sup>. Forecasting future inflation development is not goal of our analysis anyway.

Based on the above defined properties, the P\* model was estimated for the changes in the inflation rate ( $\pi_t$ ) as a reduced form of the error correction model in the following format:

$$\pi_t = a_0 + a_1 (GAP^D)_{t-1} + \sum_{j=1}^4 a_j \pi_{t-j} \quad (12)$$

$$\pi_t = b_0 + b_1 (GAP^F)_{t-1} + \sum_{j=1}^4 b_j \pi_{t-j} \quad (13)$$

$$\pi_t = c_0 + c_1 (GAP^D)_{t-1} + c_2 (GAP^F)_{t-1} + \sum_{j=1}^4 c_j \pi_{t-j} \quad (14).$$

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 Estimates of P\* model equations for the Czech Republic

	$GAP^D_{t-1}$	$GAP^F_{t-1}$	$\pi_{t-1}$	$\pi_{t-2}$	$\pi_{t-3}$	$\pi_{t-4}$	dummy	$R^2_{adj}$	S.E.R	D.W.
12a	-0,16 (-1,61)	xxx	-0,75 (-3,69)*	-0,39 (-1,63)	-0,41 (-1,70)	-0,23 (-1,15)	xxx	0,43	2,29	1,69
12b	-0,12 (-1,34)	xxx	-0,73 (-3,91)*	-0,38 (-1,74)***	-0,41 (-1,87)***	-0,18 (-0,96)	2,18 (2,25)*	0,53	2,11	1,32
13a	xxx	-0,43 (-5,04)*	-0,71 (-4,99)*	-0,34 (-2,03)***	-0,33 (-1,97)***	-0,14 (-0,99)	xxx	0,70	1,65	2,22
13b	xxx	-0,41 (-5,44)*	-0,71 (-5,79)*	-0,35 (-2,41)**	-0,35 (-2,42)**	-0,11 (-0,89)	1,94 (3,00)*	0,79	1,41	1,97
14a	-0,19 (-3,15)*	-0,45 (-6,22)*	-0,81 (-6,54)*	-0,44 (-3,04)*	-0,41 (-2,83)**	-0,22 (-1,81)***	xxx	0,80	1,39	2,02
14b	-0,16	-0,43	-0,79	-0,43	-0,41	-0,18	1,61	0,86	1,19	1,93

<sup>15</sup> The inflation rate appears stationary, although only on a 5 % significance level.

<sup>16</sup> An appropriate alternative would be a measure of inflation that does not include price deregulations, e.g. a measure of underlying inflation. However, a sufficiently long time series (beginning in 1991) is not available yet.

.	(-3,07)*	(-6,73)*	(-7,43)*	(-3,47)*	(-3,32)*	(-1,73)***	(2,92)*			
The estimation method was OLS; the dependent variable was the quarterly non-annualized inflation rate expressed in %, * 1% significance, ** 5% significance, *** 10% significance; numbers in brackets represent t-factor statistics.										

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 reverts to an equilibrium<sup>17</sup>.

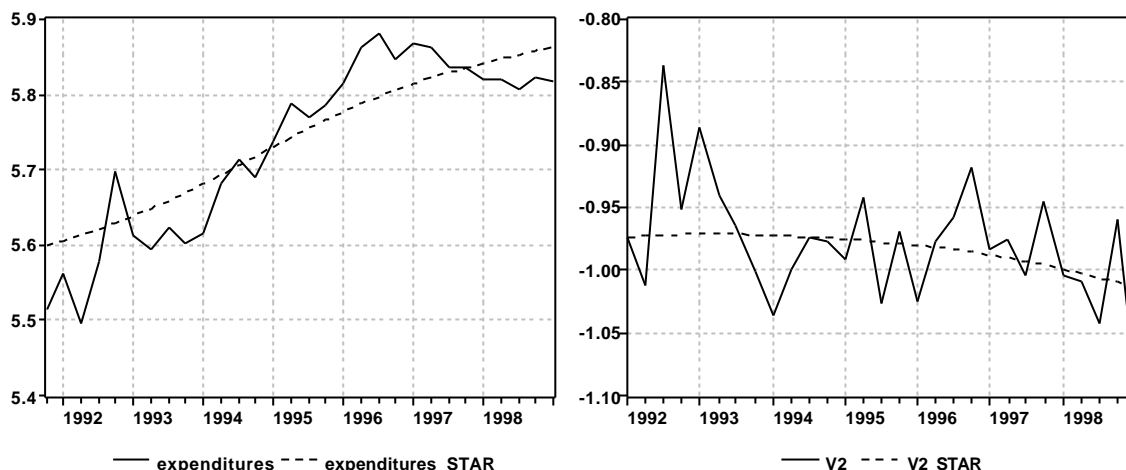
Equation (14b) can be considered a representative estimate. The result can be interpreted to indicate that a positive 1 % domestic price gap brings about a 0.16 % reduction in the inflation rate during the next quarter, whereas a positive foreign price gap of 1 % results in a 0.32 % reduction in the 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.

The level of price gaps in the beginning of 1998 may be considered as a „mild“ evidence that the model could also be used for short term inflation predictions in the Czech Republic. Both price gaps were positive which indicated a decline of inflation pressures in following quarters. Even though many institutions predicted strong inflation pressures for 1998, the actual inflation decreased as „forecasted“ out by our P\* model estimates.

Based on the previous analyses we may also consider potential inflation pressures for the end of 1999 and for the year 2000. The pressures rest on the development of the key components of inflation gaps (and equilibrium price levels) that are depicted in Figure 3. The problem is not in the foreign component where the inflation pressures are mainly based on the development of the exchange rate since the foreign (German) price conditions seem to be in equilibrium. The problem is rather in the domestic component. It is apparent from Figure 3 that both the aggregate expenditures and the M2 money velocity are significantly below their trend values. Our estimates are based on the belief that both variables will return to the trends in the future. Based on this assumption even the relatively high growth rate of M2 (8-10 %) during 1999 does not point to inflation pressures. If, however, the fall of aggregate expenditures was not only temporary but was a trend-like instead, and if the fall in the money velocity was only temporary and the falling trend would reverse in the next periods, the P\* would increase and inflation pressures would emerge if the money growth stayed at current levels.

FIGURE 3 The components of the domestic price gap

<sup>17</sup> Problematic aspects of the evaluation include a substantial standard error of the estimates and the possible autocorrelation of residuals. Given the „quality“ and short duration of the time series, these deficiencies appear acceptable.



## 6. Conclusions

The aim of this paper was to present the  $P^*$  model as a tool for inflation pressures identification and apply it to the Czech economy in the 1991-1999 period. We believe that the model could be used as one of many inflation pressures indicators within the inflation targeting regime. The foreign price gap could also act as a warning signal of potential inflation threat that is often being overlooked. We reckon that the presented  $P^*$  model includes several weak points that are given mainly by the available data set, problems with estimating equilibrium values of real income, money velocity and real exchange rate by filtering as well as by the used econometric approach. We, however, believe that the used techniques are adequate with regard to the purpose of the research and most of the time they are actually the only methods available due to the necessity to apply short time series to the model with long term properties.

The estimates of the model enable us to cautiously provide several conclusions. Above all we claim that inflation dynamics in the Czech Republic follows the premises of the  $P^*$  model: current inflation tends to close the price gap (that is a price gap between the actual and equilibrium price levels) from the previous period. The foreign component of the price gap seems to be more relevant for this than the domestic one. This results confirms the hypotheses that equilibrium price level in the Czech Republic is significantly affected by the German monetary policy through the explicit and implicit connection of the crown's exchange rate to DEM (EUR).<sup>18</sup> The domestic price level in the same time gradually adjusts to its medium term and long term trend value, which confirms the belief that CNB's monetary policy, may have a significant impact on domestic economic activity. The results also confirm the conclusions of other authors who state that the relation between money and nominal domestic expenditures is stronger than the one between money and nominal product in the Czech Republic. Inflation in the Czech Republic is nevertheless a monetary phenomenon, i.e. it mirrors the gap between the development of money supply and money demand.

<sup>18</sup> The change of exchange rate regime in 1997 that may introduce a structural break presents a great complication while applying the  $P^*$  model to the Czech reality. The weight of the domestic price gap should increase and the weight of the foreign price gap should decrease after the transition to floating. We have decided to ignore the fact due to the short data series available and due to the need of keeping the model as simple as possible. The intuition behind this is that the „strong“ crown was one of the important goals of the authorities even though the official rhetoric was different. It will, however, be necessary to take this factor into consideration in the future and undertake coefficient stability tests as well as adjusting the econometric specification of the model in the appropriate way.

## References:

- Fels, J., Mayer, T.: Money and Prices in a Mini-EMU. German Economic Commentary No. 6/1995, International Economics Research, Goldman-Sachs 1995.
- Groeneveld, H.: Monetary Spill-Over Effects in the ERM: the Case of Austria, a Former Shadow Member. Oesterreichische Nationalbank Working Paper, 1995, No. 20.
- Hallman, J.; Porter, R.; Small, D.: Is the Price Level Tied to the M2 Monetary Aggregate in the Long Run? American Economic Review, September 1991.
- Hoeller, P.; Poret, P.: Is P-Star a Good Indicator of Inflationary Pressures in OECD Countries? OECD Economic Studies, Autumn 1991, No. 17.
- Kool, C.; Tatom, J.: The P-Star Model in Five Small Economies. Federal Reserve Bank of St. Louis Review, 1994, No. 3.
- Tatom, J.: The P-Star Approach to the Link between Money and Prices. Federal Reserve Bank of St. Louis Working Paper 90-008, 1990.
- Tödter, K-H.; Reimers, H-E.: P-Star as a Link between Money and Prices in Germany. Weltwirtschaftliches Archiv, 1994, No. 2.
- Wesche, K.: Die Geldnachfrage in Europa. Aggregations Probleme und Empirie. Heidelberg, Physica-Verlag 1998.