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Equilibrium Exchange Rate in the Czech Republic: How Good is the Czech BEER?

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1. Introduction

After EU enlargement was accomplished in May 2004, the next challenge of economic integration that new EU Member States, among others the Czech Republic, face is the adoption of the euro. This issue is strongly related to the assessment of the equilibrium exchange rate, for which several concepts are available. One variant is the *Fundamental Equilibrium Exchange Rate* (FEER) developed by Williamson (1994), which defines the equilibrium exchange rate as the real exchange rate that satisfies simultaneously internal and external balances. The cornerstone of this approach is current account sustainability, i.e. the level of current account deficits/surpluses that matches long-term capital inflows/outflows. Šmídková (1998) applies FEER to the Czech Republic whereas Šmídková et al. (2002) and Bulíř and Šmídková (2004) use the foreign debt-augmented FEER termed the *Fundamental Real Exchange Rate* (FRER).

Similar in spirit to these approaches is the NATREX (*NATural Rate of EXchange*) model advocated by Stein (1994, 1995) in that it is also based on the notions of internal and external balances. However, contrary to FEER, it not only considers the medium term, but also analyses the long run, when capital stock and foreign debt are assumed to converge to their long-run steady state and the corresponding path of the real exchange rate. An application to the Czech Republic is (Frait – Komarek, 1999); the authors estimate the reduced form of NATREX.

The reduced-form NATREX is, however, very closely related to estimating the *Behavioral Equilibrium Exchange Rate* (BEER) advocated by

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MacDonald (1997) and Clark and MacDonald (1998). The BEER approach is an empirical approach linking the real exchange rate to a set of macroeconomic variables. The fitted value of the estimated equation, which may be derived either on the basis of observed series or using long-term values of the fundamentals, represents the estimated equilibrium exchange rate. Examples for an application to the Czech Republic are (Komárek – Melecký, 2003), (Rahn, 2003) and (Égert – Lommatzsch, 2004). A variant of BEER is the *Permanent Equilibrium Exchange Rate* (PEER) approach that aims to decompose the long-term cointegration vector (fitted value) into a permanent and transitory component with the permanent component being interpreted as the equilibrium exchange rate. Alberola (2003) and Rahn (2003) performed such an analysis for the Czech Republic.[1]

The ambition of this paper is to contribute to the systematic evaluation of the equilibrium exchange rate of the Czech koruna *vis-à-vis* the euro. In doing so, we follow a three-stage approach used in (Égert, 2005): (a) We first take a look at the deviation from absolute PPP. (b) We then analyze the extent to which and how long the koruna might have been undervalued during the 1990s, for, according to (Maeso-Fernandez et al., 2004), the presence of an initial undervaluation leads to a bias in coefficient estimates. (c) Finally, we apply the stock-flow approach to the real exchange rate connecting the real exchange rate to the dual productivity differential and the net foreign assets position (Faruqee, 1995) and (Alberola et al., 1999) to derive real misalignment figures interpretable in policy terms. The use of monthly time series data from 1993:M1 to 2004:M9 and of alternative cointegration techniques indicates the following pattern: overvaluation in 1997 and in 1999, an increasing overvaluation till 2002, and a correction towards equilibrium going into undervaluation by 2004.

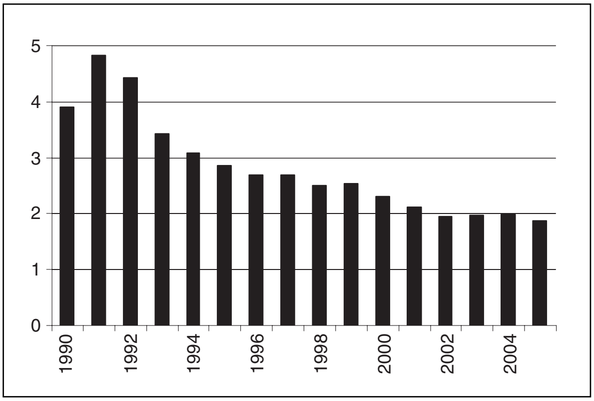
The remainder of the paper is as follows: Section 2 provides an overview on the deviation from absolute PPP and on the initial undervaluation. Section 3 outlines the stock-flow approach to the real exchange rate. Section 4 describes the dataset, followed by Section 5 presenting the estimation strategy. Section 6 overviews and discusses the estimation results and, lastly, Section 7 provides some concluding remarks.

2. Deviations from Absolute PPP and from Relative Productivity Levels

A common starting point to infer about the optimal or equilibrium exchange rate is to use the purchasing power parity (PPP) approach. However, there is a strong consensus in the literature that neither the absolute nor the relative version of PPP is an appropriate measure for developing economies. It is a usual observation that the level of the real exchange rate of developing economies is undervalued in PPP terms. If absolute PPP held, the real exchange rate should equal 1. However, *Figure 1* clearly indicates that the real exchange rate in the Czech Republic has been considerably undervalued from 1990 to 2003.

[1] For recent surveys on equilibrium exchange rates, see e.g. (Driver – Westaway, 2004) (Égert – Halpern – MacDonald, 2004).

FIGURE 1 The Real Exchange Rate in Levels vis-à-vis the Euro Area, 1990–2003



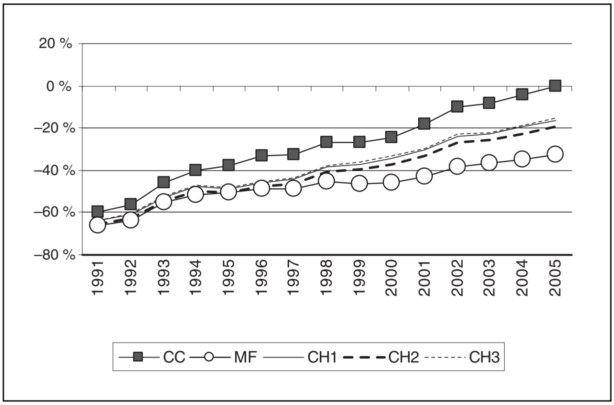
Source: WIIW, Countries in Transition 2004. Authors' estimations for 2004 and 2005.

Note: The real exchange rate is calculated as *EP*/P*, where *P** and *P* denote the absolute price level in the euro area and in the Czech Republic, and *E* is the nominal exchange rate. Figures higher (lower) than 1 indicate undervaluation (overvaluation).

However, in the baseline scenario, this is an equilibrium undervaluation, mostly because it reflects differences in relative productivity levels. But we can also think of the case where the observed real exchange rate is more undervalued than what relative productivity levels would justify. Several papers documented that transition economies in Central and Eastern Europe had such an undervaluation, commonly termed "initial undervaluation", at the beginning of the transition process in the early 1990s (Halpern – Wyplosz, 1997) and (Krajnyák – Zettelmeyer, 1998). Recently, Maeso-Fernandez et al. (2004) have shown that a strong initial undervaluation could lead to an upward bias of the estimated coefficients and the derived equilibrium exchange rate in a BEER-type of estimation.

Initial undervaluation in terms of relative productivity levels can best be analyzed using cross-sectional data by regressing the level real exchange rate/relative price level on relative productivity levels. In empirical studies, GDP per capita (measured in purchasing power standards) are used because of data availability issues. Coudert and Couharde (2003) use a sample of 120 developing and emerging countries, Maeso-Fernandez et al. (2004) investigate this relationship for 25 industrialized OECD countries, whereas the data used by Čihák and Holub (2003) comprise the old EU-15 countries and CEECs. We use the estimation results reported in the three papers (one equation from (Coudert – Couharde, 2003) and (Maeso-Fernandez et al., 2004), and three equations from (Čihák – Holub, 2003)) to derive the fitted values of the level of the real exchange rate (relative price level) for the Czech Republic, which are subsequently compared to the observed level real exchange rate/relative price level against the EU-15 (a proxy for the euro area). It should be noted that if there is initial undervaluation, the Čihák and Holub equations, and to a lesser extent the equations devised by Coudert and Couharde would be affected by the resulting bias, while the Maeso-Fernandez et al. (2004) equation would not. This is why

FIGURE 2 Under- and Overvaluations in Terms of Relative Productivity Levels



Sources: Authors' calculations. CC denotes (Coudert – Couharde, 2003), MF is (Maeso-Fernandez – Osbat – Schnatz, 2004), and CH1, CH2 and CH3 are the three regressions taken from (Čihák – Holub, 2003).

Note: A positive (negative) figure indicates overvaluation (undervaluation).

we focus hereafter primarily on results obtained on the basis of Maeso-Fernandez et al. (2004) and Coudert and Couharde (2003). The results plotted in *Figure 2* clearly indicate large initial undervaluation in 1991, and a progressive convergence towards equilibrium. Nonetheless, the Maeso-Fernandez et al. (2004) results show that the initial undervaluation was rather stable from 1994 onwards. In this sense, our time series estimations would be only slightly inflicted by the bias. The adjustment based on (Coudert – Couharde, 2003) is, however, rather steady, which points to the direction of possible biasness of the time series coefficients. If such a rapid convergence did indeed occur, then time series estimations may be thought of as tracking down deviations on the path towards equilibrium.

3. Tested Relationships

Following e.g. Faruqee (1995) and Alberola et al. (1999), we use the stock-flow approach to the real exchange rate, according to which the real exchange rate based on the CPI (Q^{CPI})[2] can be linked to the dual productivity differential (*PROD*) and to net foreign assets (*NFA*). The reduced-form equation commonly used is the following:

$$Q^{CPI} = f\,(PROD,\ NFA) \qquad (1)$$

This approach has been applied to industrialized countries by, for instance, Faruqee (1995), Aglietta et al. (1998) and Alberola et al. (1999, 2002) and to transition economies in Central and Eastern Europe by Rahn (2003),

[2] The exchange rate is defined as units of domestic currency per one unit of foreign currency, which implies that a decrease (increase) can be interpreted as an appreciation (depreciation) of the exchange rate.

Alberola (2003), Égert, Lahrèche-Révil and Lommatzsch (2004) and Égert (2005).

In this framework, an increase in the productivity variable is expected to lead to an appreciation of the real exchange rate (negative sign). Alberola et al. (1999, 2002) and Rahn (2003) interpret this as the traditional B-S effect.[3] The productivity variable for industry can also reflect non-price competitiveness in the open sector and thus lead to a real appreciation of the exchange rate as argued in (Égert – Lahrèche-Révil – Lommatzsch, 2004). To test this hypothesis, equation (1) is re-specified using the tradable prices-based real exchange rate (Q^{PPI}).

$$Q^{PPI} = f\,(PROD,\ NFA) \tag{2}$$

The class of New Open Economy Macroeconomics (NOEM) models shows, however, that an increase in productivity can also lead to a depreciation of the real exchange rate. This would imply a positive sign between the real exchange rate and productivity. For instance, MacDonald and Ricci (2002) develop a static general equilibrium model with imperfect substitutability and product variety. This model shows that productivity gains have both an appreciating and a depreciating effect on the real exchange rate. Increases in productivity in the open sector not only increase the relative price of non-tradables (real appreciation through non-tradable prices) but also decrease the price of domestically produced tradable goods relative to that abroad (real depreciation) if there is home bias. Overall, if the share of non-tradable goods is not too small in the consumer price index, the Balassa-Samuelson effect will outweigh the decrease in tradable prices, and will lead to an overall appreciation. Benigno and Thoenissen (2003) present a dynamic general equilibrium model, which they calibrate to the UK, in which the drop in tradable prices is more important than the increase in non-tradable prices. Hence, productivity gains in the open sector cause the real exchange rate to depreciate.

As far as net foreign assets are concerned, the expected sign is ambiguous for transition and emerging economies due to the following reasons. These economies need foreign savings to finance their economic growth and catching-up process. Therefore, in the long-term, the desired net foreign assets position may be negative. Thus, an inflow of foreign capital, mainly FDI, may cause the real exchange rate to appreciate (positive sign). However, in the longer term, once net foreign liabilities attain a given threshold, the home country will have to start paying interest on net foreign liabilities. In so doing, any additional increase in net foreign liabilities would lead to a depreciation of the real exchange rate (negative sign) – see (Égert – Lahrèche-Révil – Lommatzsch, 2004).

[3] In the original formulation of the B-S effect, the real exchange rate growth rate is linked to the growth rate of the difference between domestic and foreign dual productivity (the ratio of total factor productivity in the tradable sector relative to that in the non-tradable). Alternatively, the B-S effect can be derived in terms of the relationship in levels and using average labor productivity, for which empirical data are typically available (as opposed to total factor productivity). For detail, see (Égert – Halpern – MacDonald, 2004).

4. Data

The data set used in the paper contains monthly series of the bilateral real exchange rate *vis-à-vis* the euro area, average labor productivity and net foreign assets for the period running from 1993:M1 to 2004:M9. The real exchange rate, productivity and net foreign asset series are set to 1 in 1993:M1, are seasonally adjusted if needed and transformed in natural logarithms.

The real exchange rates deflated by means of the CPI and the PPI (q^{CPI}, q^{PPI}) are calculated using the nominal exchange rate against the euro obtained from the monthly database of the Vienna Institute of Comparative Economic Studies (WIIW). Average labor productivity in industry is computed as average labor productivity (industrial production over industrial employment) in the Czech Republic relative to that in the euro area. The data are obtained from the OECD for the Czech Republic and from Eurostat for the euro area[4].

Regarding net foreign assets, we use the international investment position of the Czech economy as a whole, published by the Czech National Bank (CNB hereafter)[5]. The net foreign assets series is expressed as the ratio to nominal GDP and is taken in natural logarithms. GDP in current prices, available from the Czech Statistical Office, is seasonally adjusted using the X-12 procedure. For estimation purposes, the constructed quarterly series is then linearly converted to monthly frequency. *Figure 3* plots the series used in the paper.

5. Estimation Methods

Preliminary unit root tests applied to the data suggest that most series are non-stationary.[6] Therefore, we need to perform cointegration analysis. We use the dynamic ordinary least squares (DOLS) suggested by Stock and Watson (1993) and the auto-regressive distributed lag (ARDL) approach proposed by Pesaran and Shin (2001). DOLS incorporates lags and leads of

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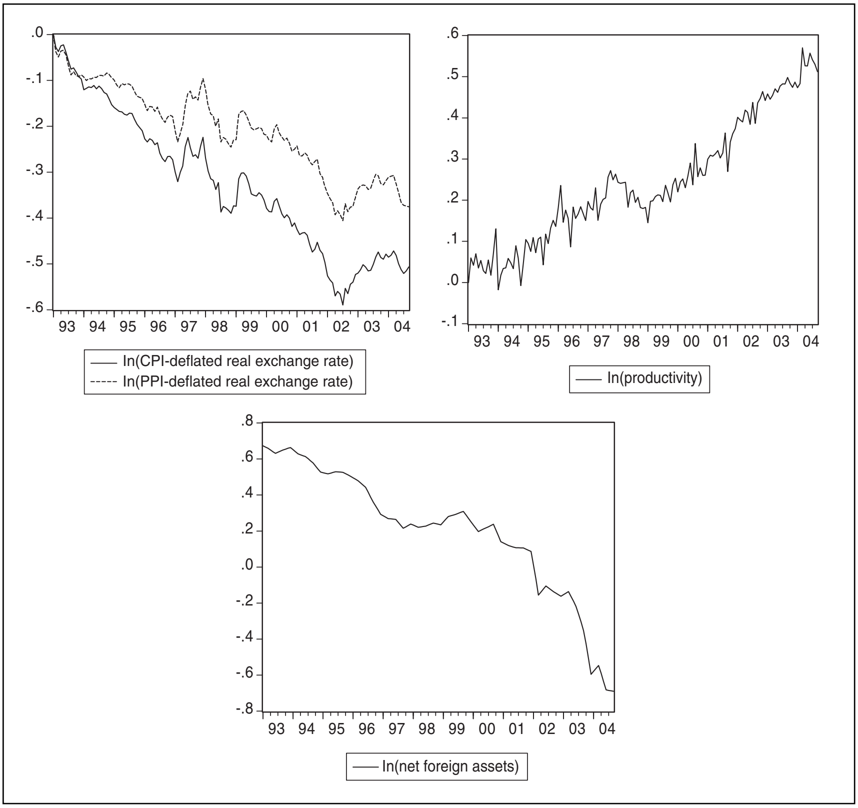
[4] For an alternative measure of average labor productivity, such as output per hour, the Czech data are available only from 2001:M1 onwards (estimates exist from 2000:M1) which is still too short a period compared to our sample.

[5] In most empirical studies, net foreign assets are proxied by either the net foreign assets (NFA) of the banking sector or cumulated current account balances. We also experimented with these two variables. Regarding NFA of the banking sector, the Czech Republic is a special case, which renders this series a fairly good approximation of the NFA of the whole economy. The reason for this is as follows: NFA series of the banking sector mainly reflects interventions of the CNB. These interventions are triggered by large FDI inflows, which contributes to a large build-up in FDI liabilities (decrease in overall NFA). The large decrease in overall net foreign assets in the Czech economy is the consequence of huge FDI inflows (FDI liabilities). Provided the CNB's interventions are proportionate to FDI inflows, an increase in the NFA position of the banking sector corresponds to a decrease in the overall NFA position of the Czech economy. Hence, the banking sector's NFA position may mirror the overall NFA position and could be viewed as a fair proxy.

[6] The results of the augmented Dickey-Fuller and Phillips-Perron unit root tests are available upon request.

FIGURE 3 Overview of the Data Used in the Study, 1993–2004



the regressors in first differences and thus accounts for the endogeneity of the regressors and for the serial correlation in the residuals:

$$Y_t = \beta_0 + \sum_{i=1}^{n} \beta_i X_{i,\,t} + \sum_{i=1}^{n} \sum_{j=-k_1}^{k_2} \gamma_{i,\,j}\, \Delta X_{i,\,t-j} + \varepsilon_t \tag{3}$$

where k_1 and k_2 denote, respectively, leads and lags. The length of leads and lags is determined on the basis of the Schwarz, Akaike and Hannan-Quinn information criteria. The presence of cointegration is assessed upon stationarity of the residuals ε_t obtained from the long-term relationship (4), in a way similar to the Engle-Granger approach[7].

$$Y_t = \beta_0 + \sum_{i=1}^{n} \beta_i X_{i,\,t} + \varepsilon_t \tag{4}$$

Stationarity of the regression residuals ε_t is tested by applying the augmented Dickey-Fuller (ADF) unit root test:

[7] See (Montalvo, 1995) for detail on the finite-sample properties of the DOLS estimator.

$$\Delta\varepsilon_t = a_1\varepsilon_{t-1} + \sum_{i=1}^{n} a_{i+1}\Delta\varepsilon_{t-i} + \nu_t \qquad (5)$$

Since the actual distribution of regression residuals ε_t is not known, special critical values of the ADF statistics should be used to assess stationarity. Critical values can be obtained using the following formula: $C_k (p, T) = \beta_\infty + \beta_1 T^{-1} + \beta_2 T^{-2}$ where p and T are the significance level and the sample size respectively, and the betas are parameters of response surface estimates provided in (MacKinnon, 1991).

The ARDL approach is an alternative way of assessing the cointegration relationship. The variables can be integrated of different order, e.g. I(0) and I(1). The error correction form of the ARDL model is given by equation (8); where the dependent variable in first differences is regressed on the lagged values of the dependent and independent variables in levels and first differences.

$$\Delta Y_t = \beta_0 + \rho(Y_{t-1} + \sum_{i=1}^{n}\beta_i X_{i,\,t-1}) + \sum_{j=1}^{l_1}\eta_j \Delta Y_{t-1} + \sum_{i=1}^{n}\sum_{j=0}^{l_2}\gamma_{i,\,j}\,\Delta X_{i,\,t-j} + \varepsilon_t \qquad (6)$$

To detect the presence of cointegrating relationships, Pesaran et al. (2001) employ the so-called bounds testing approach. Using conventional F-tests, the null of $H_0 : \rho = \beta_1 = ... = \beta_n = 0$ is tested against the alternative hypothesis of $H_1 : \rho \neq 0, \beta_1 \neq 0, ..., \beta_n \neq 0$. Pesaran et al. (2001) tabulate two sets of critical values, one for the case when all variables are I(1), i.e. upper bound critical values and another one when all variables are I(0), i.e. lower bound critical values. Critical values are provided for five different models, of which model (3) with unrestricted intercept and no trend will be used in our study. If the test statistic is higher than the upper bound critical value, the null of no cointegration is rejected in favor of the presence of cointegration. On the other hand, an F-statistic lower than the lower bound critical value implies the absence of cointegration. In the event that the calculated F-statistic lies between the two critical values, there is no clear indication of the absence or existence of a cointegrating relationship.

6. Results

6.1 Estimation Results

The estimations are performed for the CPI- and PPI-based real exchange rate, using the average labor productivity series (PROD) and net foreign assets (NFA) for the whole period (1993:M1 to 2004:M9) and for a more recent period (1997:M6 to 2004:M9) to minimize the impact of the initial transformation process.[8] These four equations are estimated using two cointegration techniques (DOLS and ARDL) combined with the use of four

[8] To perform sensitivity checking, we select two alternative sub-periods, starting from 1996:M6 and 1997:M1 respectively. The results for these sub-periods are similar and are available upon request.

TABLE 1a Estimation Results

Dependent variable: CPI-based real exchange rate							
	1993–2004			1997–2004			
	DOLS	**ARDL**	**ARDL**	**DOLS**	**DOLS**	**ARDL**	**ARDL**
LAG	(6,6), S,A,H,F	(6,0) A,H	(6,6) F	(0,0), S	(6,6), A,H,F	(6,0) A,H	(6,6) F
COINT	–3.939** (3) S,A,H	9.513**	7.747**	–4.053** (6) F	–4.526** (0) S	10.440**	8.386**
ECT	–0.035*	–0.067**	–0.072**	–0.078**	–0.054**	–0.162***	–0.156***
	(0.018)	(0.024)	(0.029)	(0.034)	(0.026)	(0.041)	(0.047)
	Coefficients			**Coefficients**			
CONST	0.286***	0.113	0.125	–0.069	0.256***	–0.057	–0.038
	(0.065)	(0.154)	(0.209)	(0.048)	(0.071)	(0.093)	(0.124)
PROD	–2.228***	–1.575**	–1.636*	–1.065***	–2.076***	–1.104***	–1.127*
	(0.192)	(0.637)	(0.901)	(0.143)	(0.211)	(0.382)	(0.569)
NFA	–0.523***	–0.334	–0.343	–0.173***	–0.594***	–0.227**	–0.268
	(0.090)	(0.204)	(0.297)	(0.056)	(0.100)	(0.112)	(0.176)

Notes: DOLS and ARDL are the Dynamic OLS and the Autoregressive Distributed Lags estimations. LAG denotes the lag structure of the DOLS and ARDL model: leads and lags for DOLS and *dY* and *dX* for ARDL. S, A, H and F indicate that the lag structure is based upon the Schwarz, Akaike, Hannan-Quinn information criteria or the fixed lags of 6, respectively. COINT contains the residual-based cointegration results for DOLS, and the *F*-statistics for the ARDL. For DOLS, the single number in COINT indicates the lag length in the unit root tests of the residuals. ECT is the error correction term. CONST is the constant term, PROD is the productivity variable, and NFA is net foreign assets. Standard errors are in parentheses. *, ** and *** denote the 10%, 5% and 1% significance levels, respectively.

TABLE 1b Estimation Results

Dependent variable: PPI-based real exchange rate							
	1993–2004				1997–2004		
	DOLS	**DOLS**	**ARDL**	**ARDL**	**DOLS**	**ARDL**	**ARDL**
LAG	(0,0) S	(6,6) A,H,F	(6,0) A	(6,6) F	(0,0) S	(6,0) A	(6,6) F
COINT	–4.109** (3) S,H	–4.483** (3) S, A, H	8.241**	6.417**	–3.922** (6) F	7.219**	5.100**
ECT	–0.090***	–0.055**	–0.149***	–0.161***	–0.074**	–0.192***	–0.188***
	(–0.031)	(0.022)	(0.037)	(0.042)	(0.037)	(0.048)	(0.055)
	Coefficients				**Coefficients**		
CONST	–0.036	0.273***	0.014	0.039	–0.013	0.010	–0.001
	(0.028)	(0.052)	(0.064)	(0.087)	(0.042)	(0.075)	(0.143)
PROD	–0.688***	–1.625***	–0.821***	–0.922**	–0.760***	–0.831***	–0.800*
	(0.084)	(0.152)	(0.264)	(0.358)	(0.121)	(0.308)	(0.444)
NFA	–0.036	–0.462***	–0.100	–0.132	–0.081*	–0.134	–0.108
	(0.036)	(0.072)	(0.086)	(0.121)	(0.047)	(0.090)	(0.133)

Notes: As for Table 1a.

alternative lag selection criteria for DOLS and ARDL (Schwarz, Akaike, Hannan-Quinn and fixed lag length of 6 yielded 32 regressions in total).

Only those equations are retained for which cointegration could be established. At the end of the selection procedure, we are left with 14 equations for which both actual and total misalignments are calculated from 1997:M6 to 2004:M9 (7 equations were identified for the whole period).

Overall, the estimation results reported in *Tables 1a-1b* indicate that productivity and net foreign assets enter the equation with a negative sign. An increase in the productivity variable leads to an appreciation of the real exchange rate. Importantly, the productivity variable is found to cause an appreciation not only of the CPI-based real exchange rate but also of the PPI-based real exchange rate. The implications of these results are that the predictions of the NOEM models (depreciation through tradable prices) are not verified for the Czech Republic and that besides the Balassa-Samuelson effect, the appreciation of the overall real exchange rate is also explained by the appreciation of the tradable prices-based real exchange rate.

At the same time, a decrease in net foreign assets of the Czech economy, which is equivalent to an increase in liabilities from the international investment position view, results in an appreciation of the real exchange rate. This holds true both for the CPI-based and the PPI-based real exchange rates. The size of the coefficient estimates on productivity decreases significantly for the case of the PPI-deflated real exchange rate, while the size of the net foreign assets coefficient estimates remain broadly unchanged across the different specifications. Regarding the sign on NFA, this is something that corresponds to the medium-term effect as suggested by Égert, Lahrèche-Révil and Lommatzsch (2004). In the event that a transition economy has low initial endowment with foreign assets and if domestic savings are not enough to finance growth, then the economy needs foreign capital mirrored in accumulating foreign liabilities. Therefore, an increase in foreign liabilities might go along with domestic currency appreciation, in the mid- to long-term horizon. However, once the level of net foreign liabilities reach their long-term steady state level, the domestic economy has to start transferring interest payments and repaying its debt to non-residents. So, any additional increase in foreign liabilities would lead to a depreciation of the real exchange rate so that the domestic economy remains capable of servicing debt.

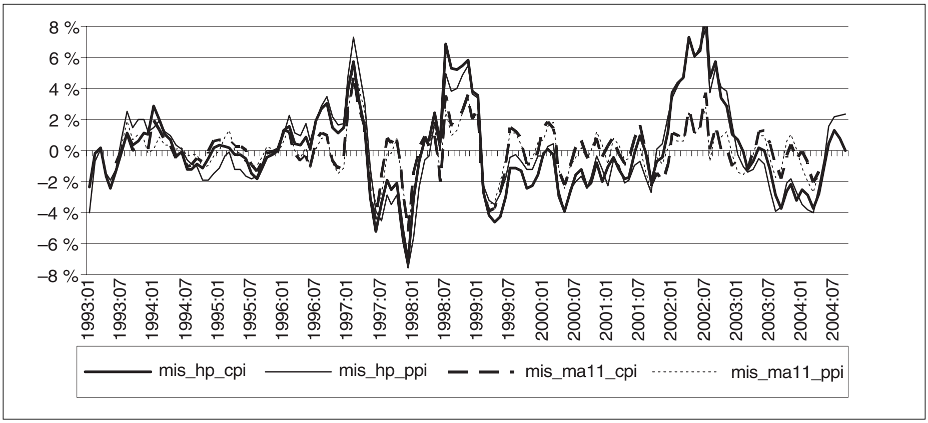
At the same time, it is necessary to mention that in some cases the results are sensitive not only to the lag structure but also to whether DOLS or ARDL is used. For instance, while using DOLS, *Table 1a* reveals two cases of cointegration detected for the CPI-based real exchange rate for the period from 1997 to 2004 and only one cointegrating relationship for the whole sample. On the contrary, *Table 1b* shows one case of cointegration for the PPI-based real exchange rate for the whole period and two cointegrating relationships for the recent sub-period when DOLS is applied. Furthermore, in some cases, the coefficient on net foreign assets becomes insignificant (mainly when using ARDL).[9]

6.2 Real Misalignments

As a benchmark for judging the dynamics of the real misalignment, we start with an illustration of the trajectory of misalignment obtained by means of popular univariate methods such as the Hodrick-Prescott filter and an 11-month moving average. This exercise is performed on the CPI- and PPI-based real exchange rate of the Czech koruna with respect to

[9] The estimated coefficients do not seem to differ across the whole period and the 1997–2004 sub-sample; at least the point estimators and the reported standard errors suggest so.

FIGURE 4 First-Glance Evidence



Source: authors' own calculations

Note: Deviation of the CPI- and PPI-based real exchange rates from the long-term component of the series obtained using the HP filter (λ = 14 400) and an 11-month moving average. Negative (positive) values indicate undervaluation (overvaluation).

the euro. Two observations can be made from visual inspection of *Figure 4*. First, there is not much difference between CPI- and PPI-based misalignments. Although the level of the real exchange rate differs when using PPI or CPI as the price deflator as shown in Figure 3, the real misalignment, which shows a deviation of the real exchange rate from its long-term trajectory, is very similar for both price indices. Second, there is some difference between two filtering techniques: the moving average method tends to give better fit and, hence, lower misalignment than the HP filter with the default value of the smoothing parameter λ = 14 400. Overall, the two filters produce qualitatively similar patterns of real misalignment: overvaluation in 1997, 1999 and 2002, and a correction towards equilibrium and a tendency to undervaluation in 2004.

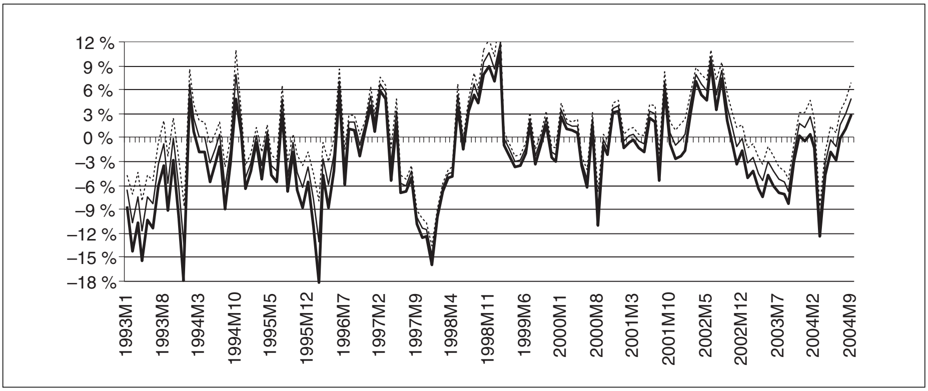
Actual misalignment is obtained as the difference between the fitted values of the selected regressions and the observed values of the real exchange rate. Total misalignment is defined as the fitted values of the selected regressions obtained on the basis of the long-term values of the productivity series (the trend produced by the Hodrick-Prescott filter is used) less the observed real exchange rate.

Figures 5 and *6* illustrate the trajectory of the real misalignment obtained from regressions. Figure 5 shows actual misalignment, defined as the difference between fitted and actual real exchange rate, and Figure 6 reports total misalignment, calculated as the long-term fitter (HP-filtered) less the actual real exchange rate value. We compute confidence intervals around the mean.[10] On each figure, the mean and the 5% confidence bands are plotted.

Total misalignment exhibits much less volatility as compared to actual

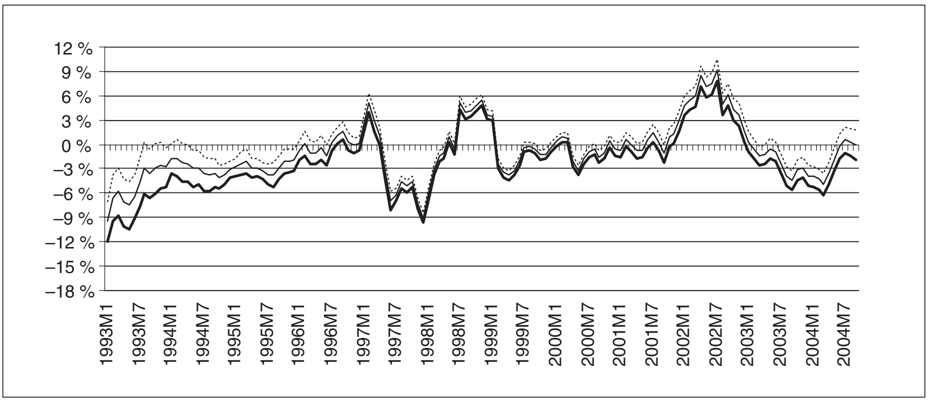
[10] Égert and Lommatzsch (2003) follow the same procedure.

FIGURE 5 Actual Real Misalignments



Source: authors' own calculations
Note: Deviation of the CPI- and PPI-based real exchange rates from the fitted values of the estimated equations. The mean and the confidence interval around it are reported. Negative figures indicate a real undervaluation. Positive values correspond to overvaluation.

FIGURE 6 Total Real Misalignments



Source: authors' own calculations
Note: Deviation of the CPI- and PPI-based real exchange rates from the fitted values of the estimated equations. The long-term component of the fundamentals is obtained using the HP-filter. The mean and the confidence interval around it are reported. Negative (positive) figures indicate a real undervaluation (overvaluation).

misalignment. Otherwise, both graphs show quite similar dynamics of misalignment, which are also qualitatively comparable to that produced by simple univariate filters. To summarize, our results suggest an overvaluation of about 4–8 % in the middle of 2002, an undervaluation of 3–10 % in 2003 and no misalignment in the second half of 2004.

The estimations are performed using not only net foreign assets for the economy as a whole but also using net foreign assets of the banking sector and cumulated current account balances.[11] The actual and real misalignments calculated on the basis of these estimations exhibit very similar size and dynamics to those reported in Figures 5 and 6.

The identified periods of real over- and undervaluation are clearly linked to the country's macroeconomic development. Let us now briefly review these developments. Since its introduction in 1993, the Czech koruna was fixed to a basket of five currencies, dominated by the US dollar (49.07 %) and the German mark (36.15 %). From May 1993, the basket was changed to the DEM (65 %) and the USD (35 %), and a fluctuation band of ±0.5 % was established. In October 1995 the Czech koruna achieved full external convertibility, as a step preceding the country's joining the OECD in December 1995. Against the background of burgeoning economic growth during 1994–1996, signs of increasing internal and external imbalances started to appear. Nonetheless, capital liberalization and the international image as one of the transition countries experiencing successful economic transformation increased interest in the national currency on foreign markets. As a result of massive inflows of (short-term) foreign capital, the Czech koruna rapidly appreciated in real terms. In order to protect the currency against the speculative capital, fluctuation bands were widened to ±7.5 % in February 1996. Relaxing the exchange rate should have signaled higher currency risk and, thus, should have restrained the inflow of short-term capital. The effect did indeed occur. However, a speculative attack of May 1997, in the form of mass selling of koruna, triggered the currency crisis. The situation was resolved by abandoning the fixed exchange rate regime and introducing the managed float. The DEM served as the reference currency, later being replaced by the EUR.

In the aftermath of the crisis the koruna depreciated, in both nominal and real terms. In January 1998 inflation targeting was introduced. A combination of disinflation and still relatively high interest rates attracted foreign capital, and in the second half of 1998 to the first half of 1999 the koruna resumed real appreciation. 2000–2001 is commonly perceived as the period of equilibrium appreciation. Another surge in appreciation occurred in 2002, caused by an increase in demand from the part of foreign investors in relation to privatization. The observed real undervaluation in 2003/early 2004 primarily reflected low interest rates and remarkably low inflation in the Czech Republic (below euro area levels). EU enlargement in May 2004 was accompanied by further inflows of foreign capital and a moderate increase in Czech prices, up to 3.5 % by the fall 2004, which corresponded to the middle of the inflation target band. The undervaluation trend of 2003 was reverted and appreciating pressures on the Czech koruna emerged in the second half of 2004.

6.3 A Comparison with the Literature

In order to compare our findings with those reported in the literature, *Table 2* summarizes empirical studies aimed at determining possible real misalignments for the Czech Republic. Although too few and far between in the late 1990s, the number of papers has increased recently. The literature, basically dominated by time-series BEER estimates shows a possible

[11] The period used for these estimations span from 1993 to only 2003. The real misalignment figures based on these estimations are available from the authors upon request.

TABLE 2 The Magnitude of Misalignment of the Czech Koruna

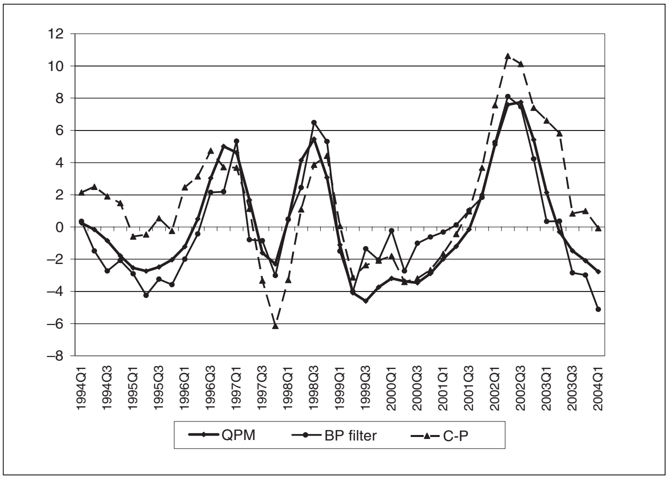
Author	Misalignment*		Econometric method	Background	Country	Estimation period
	Year	Magnitude				
1996 Šmídková (1998)	1996	Eff: -1 %...+5 %	Simult. eq.	FEER	CZ	1992–1996,Q
1997 Begg et al. (1999)	1997	Eff: NM	Panel	BEER	85 countries incl. CEEC10	1990–1997,Y
1998 Frait and Komárek (1999)	1998	Slightly +	Time series	NATREX* BEER	CZ	1992:Q3–1999:Q1
1999 Kim and Korhonen (2002)	1999	Eff: -10 %	Panel	BEER	CEEC5	1991–1999,Y
2001 Coudert and Couharde (2003)	2001	EUR: -3 %...+1 %	Simult. eq.	FEER	CZ,ES, HU,PL,SN	2000–2001,Y
Lommatzsch and Tober (2002)	2001	Eff: 0 %...+15 %	Time series	BEER*structural equations	CZ,HU, PL	1994/95–2001,Q
Égert and Lahrèche-Révil (2003)	2001:Q2	Eff: +15 %	Time series	BEER*FEER	CEEC5	1992/93–2001,Q
2002 Rahn (2003)	2002:Q1	Eff: +9.7...+11 % EUR:+13.7...+14.7 %	Time series	BEER, PEER	10 CEECs	1990/93–2002,Q
Šmídková et al. (2002)	2002	Eff: +8 %...+9 %	Simult. eq.	FEER	CZ,ES,HU, PL,SN	1996–2002,Q
Crespo-Cuaresma et al. (2003)	2002	EUR: +16 %	Panel	Monetary model	CEE5+Ro	1994–2002,M
QPM (2003) **	2002	EUR: +3 %	State space	UIP	CZ	1998–2003,Q
Komárek and Melecký (2003)	2002	EUR: +0.4 %...+1.2 %	Time series	BEER	CZ	1993–2003,Q
Alberola (2003)	2002:Q4	Eff: +10 %	Time series	BEER/PEER	CZ,HU,PL	1993–2003,Q
Égert and Lommatzsch (2004)	2002:Q4	EUR: +4 %...+30 %	Time series Panel	BEER	CEEC5	1992/94–2002,Q
Derviz (2004)	2002:12	EUR: +2 %	State space	Asset pricing model	CZ	1999:12–2003:6
2003 Bulíř and Šmídková (2004)	2003:Q4	Eff: +15 %	Panel	FEER	CZ,HU, PL,SN	1995–2003,Q
QPM (2004) **	2003:Q4	EUR: -2 %	State space	UIP	CZ	1998–2004,Q
Cincibuch and Podpiera (2004)	2003:Q4	EUR: +1 %	Time series	PPP	CZ	1998–2004,Q
This study	2003:Q4	EUR: -4 %...+4 %	Time series	BEER	CZ	1993–2004,M

Sources: (Égert – Halpern – MacDonald, 2004) and authors' updates

Notes: * Positive figures indicate overvaluation whereas negative figures stand for undervaluation; Eff: in effective terms, Eur: against the euro, NM: no misalignment.
** Quarterly projection model, Czech National Bank estimates based on methodology by Beneš et al. (2002).

overvaluation of the Czech koruna in 2001, which continued to be the case in the course of 2002. Although the direction of the misalignment turns out to be well established, the size of the overvaluation differs substantially across papers and ranges from 2 % to about 30 %. For 2003, most of the stu-

FIGURE 7 Misalignment of the Czech Koruna (%) – various approaches



Sources: QPM: quarterly projection model, CNB estimates based on methodology by Beneš et al. (2002)
BP filter: band-pass filter applied to the CPI-based real exchange rate, CNB estimates – see (Baxter – King, 1995) and (Christiano – Fitzgerald, 1999) for details on the band-pass filter
C-P: Cincibuch and Podpiera (2004)

Note: Misalignment = fitted – actual values. Positive values correspond to overvaluation.

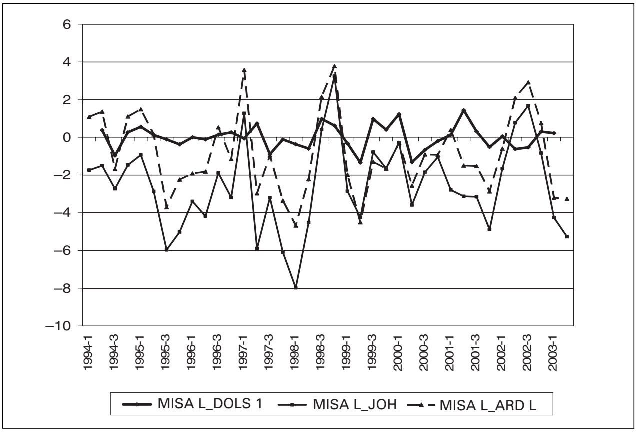
dies except for FEER find the real exchange rate close to its equilibrium by the end of the year.

A more straightforward way of comparing papers is to look at the dynamics of the derived misalignment. Different estimates of the Czech National Bank from 1998 to 2003, reported in *Figures 7* to *9*, show dynamics similar to that reported earlier in this paper: overvaluation in 1998 and 2002, and since 2003 correction towards undervaluation. However, there are important differences in levels, especially in the recent period, which might be due to the sensitivity of filtering algorithms to the end-period observations.

The misalignment trajectory labeled "QPM" is obtained from the estimation of the uncovered real interest parity equation, which links the trend in the real exchange rate with the real domestic-foreign interest rate differential and the risk premium. Actual series of the real variables are then decomposed into two components, the unobservable "equilibrium" values and deviations from these equilibrium values. The technique used to estimate the unobservable components of actual series is the Kalman filter.

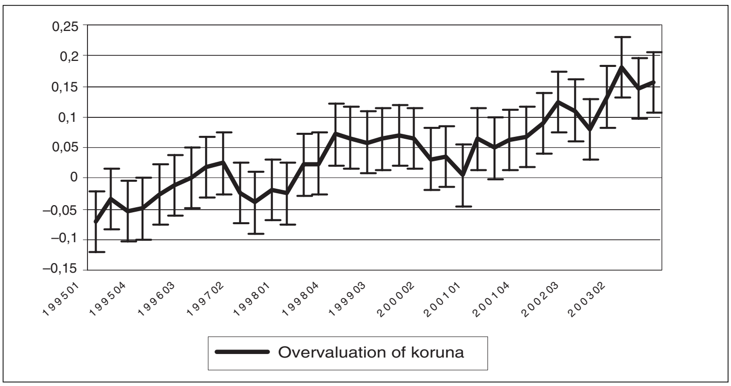
Cincibuch and Podpiera (2004) attempt to explain changes in the real exchange rate based on prices of tradables. Exchange rate changes are decomposed in 'disparity' and 'quality' foreign-domestic ratios. The 'disparity' ratio reflects changes in adjusted purchasing power and the 'quality' counterpart captures changes in relative prices of local and foreign goods. While cyclical component in the quality ratio may be attributed to varying relative cost conditions of home and foreign producers, the trend component is interpreted as a change in generalized relative quality. Drawing on sectoral data for manufacturing and mining industries for prices on local markets

FIGURE 8 Misalignment of the Czech Koruna (%) – BEER estimates



Source: (Komárek – Melecký, 2003)
Note: Misalignment = fitted – actual values. Positive values correspond to overvaluation.

FIGURE 9 Misalignment of the Czech Koruna – FEER



Source: (Bulíř – Šmídková, 2004). The graph is kindly provided by the authors.
Notes: Positive values of misalignment correspond to overvaluation. 0.05 = 5 %, etc.
Export/import elasticities are estimated over 1994/95–1999 in a panel of five new Member countries (Czech Republic, Estonia, Hungary, Poland and Slovenia).

as well as for export and import prices, it is found that the variability of the disparity and the cyclical part of the quality ratio is about of the same magnitude. The real exchange rate misalignment displayed in Figure 7 is calculated as the sum of the 'disparity' and 'quality' components.

Using quarterly data, Komárek and Melecký (2003) model the real CZK/EUR(DEM) exchange rate as a function of the current account balance as a share of GDP, the share of foreign direct investment in GDP, productivity measured as GDP per employee, the terms of trade, the ratio of PPI to CPI to capture the Balassa-Samuelson effect, and the average of the LIBOR rate on the euro (DEM) and the U.S. dollar.

Finally, Bulíř and Šmídková (2004) present evidence on misalignment from the FEER-type approach. Elasticities of export and import functions, estimated over 1994/95:Q1 to 1999:Q4 in a panel of five new Member states[12], and the 1995:Q1–2003:Q3 actual values of the variables serve as inputs for the 4-equation structural model. The resulting misalignment is illustrated on Figure 9.

Comparing the dynamics of misalignment from various approaches (Figures 7 to 9), one can notice that during 1995–1999 there is some similarity between the alternative estimates: undervaluation in 1995, followed by overvaluation in 1996, again undervaluation during mid-1997 to mid-1998 and slight overvaluation for the rest of 1998–1999. Since 2000, however, the FEER-type estimates demonstrate an explicit upward-sloped trend (also noticeable through the whole period), which leads to a total misalignment of about 15 % by the end of 2003. The other methods show a correction towards equilibrium/undervaluation during the 2003–2004 episode. Overall, the results of FEER go in sharp contrast with other recent studies for the Czech Republic. Even though the alternative approaches such as statistical methods, BEER, macroeconomic disparity and uncovered interest parity are very different, they have some similar patterns of misalignment, e.g. mean reversion.

Such a difference between the FEER-type and the other approaches might be due to, *inter alia*, a limited relevancy of FEER parameters calibrated over 1995–1999 to reflect the 2000–2003 dynamics. Other reasons for a trend-like behavior of FEER estimates, except the use of outdated key parameters, might be a lack of sensitivity (robustness) tests, work with heterogenous panel (no formal testing for common slopes), and some ad-hoc assumptions about the 'sustainable' external sector.

7. Conclusions

In this paper we attempted to put to the test the reduced-from equation of the stock-flow approach to the real exchange rate using data for the Czech Republic. This approach links the real exchange rate to productivity accounting for trend appreciation and net foreign assets.

Our estimation results indicate some standard characteristics of real exchange rates in transition economies in that an increase in productivity leads to an appreciation of the real exchange rate. On the other hand, our results contribute to the debate on net foreign assets. The analysis of the literature suggests that some studies find a positive relationship whereas others find a negative relationship between the real exchange rate and net foreign assets. Égert, Lahrèche-Révil and Lommatzsch (2004) suggested that a positive relationship between net foreign assets and the real exchange rate, i.e. when a decrease in NFA leads to a real appreciation, is a medium-term phenomenon. However, once a given economy surpasses a given level of negative net foreign assets, the relationship reverses because of the need to service the stock of net foreign liabilities. Our results indicate that

[12] Czech Republic, Estonia, Hungary, Poland and Slovenia

the Czech Republic is still in the medium-term regime and that the turning point is still to come in the future.

Using alternative cointegration techniques, we obtained a number of real misalignment figures for the period from 1993:M1 to 2004:M9. The real misalignment corridor, given by confidence intervals at the 5% level around the mean, shows the following pattern: overvaluation in 1997, 1999 and an increasing overvaluation till 2002, undervaluation in 2003 and then a correction towards equilibrium in 2004. Notice that in a low inflationary environment, nominal misalignment might become almost synonymous to real misalignment. At least, the difference between nominal and real numbers, given by aggregate inflation (which was about 1 % in 2003 and 2 % in 2004), is much smaller than the uncertainty involved in calculations of real exchange rate misalignment.

We also studied the impact of a possible initial undervaluation on the estimated equilibrium exchange rate. According to Maeso-Fernandez et al. (2004), a strong initial undervaluation could lead to overestimation of the equilibrium exchange rate. As a result, overvaluation of the real exchange rate may be observed, particularly noticeable at recent periods. Based on the derived fitted values of the level real exchange rate from the available cross-sectional studies, we conclude that there is strong evidence for undervaluation for the pre-1993 period, and a progressive correction being rather stable from 1994 onwards. Our time series estimations may be though of as tracking down deviations on the path towards equilibrium.

It should be stressed that the reported misalignment based on time series estimates are to be taken with care and should be interpreted at the short- and medium-term horizon (approximately one to four years). Firstly, we only used one theoretical approach. A future research path would be to look at different theoretical approaches for the case of the Czech Republic, including the FEER approach and its variants, i.e. the FRER and the MB approach, the NATREX model and different BEER and PEER specifications. Secondly, we only assessed the equilibrium exchange rate on the basis of time series. Égert and Halpern (2005) argue that time series estimates may provide relatively short-term estimates whereas panels may tend to yield equilibrium exchange rate estimates that apply at longer time horizons. In other words, real misalignments derived from time series estimates average out over time and hence are not long-lasting, while those obtained from panels, especially of larger size, may indicate a permanent deviation of the real exchange rate from its equilibrium value.

To summarize, and turning back to the initial question raised in the title, namely “How good is the Czech BEER?”, it is certainly fair to say that the Czech BEER is of fine quality. Nonetheless, there are many types of BEERs available on the market and our answer rests only on the time series BEER. Perhaps panel BEERs would be of different quality. Even worse, some would prefer FEER or NATREX to BEER. It is, however, hard to imagine the Czech Republic without any kind of BEER.

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SUMMARY

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Equilibrium Exchange Rate in the Czech Republic: How Good is the Czech BEER?

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The paper investigates the equilibrium exchange rate of the Czech koruna using the reduced-form equation of the stock-flow approach advocated by, for example, Faruqee (1995) and Alberola et al. (1999). We investigate whether the observed real exchange rate of the Czech koruna is close to its equilibrium value over the period from 1993 to 2004. Our empirical approach is tantamount to the behavioral equilibrium exchange rate (BEER), popularized by MacDonald (1997) and Clark and MacDonald (1998), in that the Czech real exchange rate vis-à-vis the euro is regressed on the dual productivity differential; and the net foreign assets position, based on which actual and total misalignment figures, are derived in a time-series context. In other words, we check the quality of the Czech BEER. We also study the impact of a possible initial undervaluation on the estimated equilibrium exchange rate. Employing monthly time series from 1993, and applying several alternative cointegration techniques, we identify a period of an overvaluation in 1997 and in 1999, an increasing overvaluation afterwards, an undervaluation in 2003, and a correction toward equilibrium in the second half of 2004.