Testing for Efficiency in Selected Developing Foreign Exchange Markets: An Equilibrium-based Approach.

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Abstract

This paper proposes an alternative way of testing FOREX efficiency for developing countries. The FOREX market will be efficient if fully reflects all available information. If this holds, the actual exchange rate will not deviate significantly from its equilibrium rate. Moreover, the spot rate should deviate from its equilibrium rate by only transitory components (i.e. it should follow a white noise process). This test is applied to three Central & Eastern European Countries – members of the EU. Considering an LSTAR model we find no evidence of nonlinear adjustment in the misalignment series. So, linear unit root tests imply that the Poland/Euro FOREX market is efficient, the Czech/Euro FOREX market is not, while the Slovak/Euro FOREX market is quasi-efficient.

Keywords: FOREX efficiency; BEER; Linearity test; Unit Root.

JEL Classification: C12, C32, C51, E58, F31.

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1. Introduction

Efficient Market Hypothesis (EMH) relies on the efficient exploitation of information by economic actors. EMH is also referred as Informational Efficiency (Hallwood & MacDonald, 1994). For example, an asset market is efficient if the asset price fully reflects all available information. EMH requires that market agents have rational expectations and there are no transaction costs that avert them from buying and selling assets. Fama (1984) states that a foreign exchange market is efficient if fully reflects all available information. A weaker-form, presented by Jensen (1978), states that an efficient market reflects information up to the point where the marginal benefit of information does not exceed the marginal cost of collecting it. Foreign Exchange Efficiency Hypothesis is also called as Forward Rate Unbiasedness Hypothesis (hereafter, FRUH), because in an efficient market the forward rate should be unbiased (or good) predictor of the future spot rate.

All the above statements imply numerous test procedures for examining the efficiency hypothesis. The majority of the empirical studies apply conventional OLS and univariate as well as multivariate cointegration techniques to test FRUH. A seminal study is that of Fama (1984), which examines efficiency in nine exchange rates (nine currencies against US dollar), using monthly data from 1973:8 to 1982:12. OLS estimation shows that the market efficiency hypothesis is not accepted because of a time-varying risk premium. Similarly, Naka & Whitney (1995) test the efficiency hypothesis of seven exchange rates (against US dollar) from 1974:1 to 1991:4 (monthly observations). OLS estimation rejects the FRUH. In contrast, they manage to accept this hypothesis through Non-Linear Least Squares estimation. Hakio (1981) examines five exchange rates against US dollar from 1973:4 to 1977:5. In all cases, the unbiasedness hypothesis cannot be accepted. Taylor (1989) examines the US dollar/UK pound exchange rate from January 1981 to July 1985. He finds statistically significant risk premium, so there is evidence of risk-averse behavior. He also tests the rationality of expectations but, he cannot accept the hypothesis that expectations are not rational. Therefore, risk aversion rather than non-normality causes the rejection of the efficiency hypothesis.

Zivot (2000) tests the foreign exchange market efficiency for the British pound, Japanese Yen, Canadian dollar against US dollar from 1976:1 to 1996:6 (monthly observations). He compares cointegration models between the forward rate with the current spot rate and the forward rate with the future spot rate. He finds that cointegration analysis in the first case, estimating a VECM, strongly rejects the efficiency hypothesis in all exchange rates. Hakkio & Rush (1989) examine the efficiency hypothesis for the UK pound and the Deutsche mark from 1975:1 to 1986:10 (monthly observations). They find that spot and forward rates, within a country, are cointegrated, which is consistent with efficiency. But, the estimation of the error correction model rejects the hypotheses of no risk premium and efficient use of the available information by the agents. These findings reject the foreign exchange market efficiency hypothesis. A multivariate cointegration analysis in an international framework, performed by Baillie & Bollerslev (1989), shows that spot rates are cointegrated. This finding is interpreted by the authors as a violation of the efficiency hypothesis because the disequilibrium error can predict the future change in the spot rate.[1] Other studies in that field, providing mixed implications about market efficiency, are those of Sephton & Larsen (1991); Corbae et. al. (1992) and Dutt (1994).

Although the FRUH is appropriate for testing FOREX efficiency between developed markets, this is not suitable when developing counties is the case. These countries do not have well-developed and independent from the government financial systems. Therefore, forward rates may be highly regulated and as a consequence inappropriate for deriving any inferences about foreign exchange efficiency. In some cases, forward markets are totally absent and the forward rates are unavailable. Aron (1997) proposes a test of foreign exchange efficiency by regressing the long run relationship of the spot rate with a vector of fundamentals.[2] Although, Wickremasinghe (2004) applies a cointegration test in

[1] A lot of criticism has been applied to this type of test. For instance, Hodrick (1987) describes as false the above statement about the predictability of the future spot rate. Similarly, Baffes (1994) argues that efficiency does not require unpredictable exchange rates. Actually, efficiency is weakened only if arbitrage opportunities can arise from predictability. Moreover, Engel (1996) does not accept that two spot rates, in a pair of efficient markets, should not be cointegrated and argues that foreign exchange market efficiency does not require unpredictable spot rates. Furthermore, Dwyer & Wallace (1992) show that there is no evidence of market inefficiency if two exchange rates are cointegrated.

[2] He uses an error correction model to examine the predictability of future excess returns via the lagged disequilibrium error term. This test entails a two-step procedure. Firstly, evidence of cointegrating vectors between the spot rate and the vector of fundamentals implies that exchange rate movements can be

the case of a developing country, we cannot adopt this methodology[3]. Hodrick (1987); Baffes (1994); Engel (1996) and others emphasize the invalid properties of this test. As a consequence, the empirical tool for testing this hypothesis in developing markets is still missing.

This paper proposes an alternative way of testing Foreign Exchange Market Efficiency Hypothesis for Developing Countries. This methodology is based on the Behavioral Equilibrium Exchange Rate (Clark & MacDonald, 1998). The FOREX market will be efficient if fully reflects all available information. If this holds, the actual exchange rate will not deviate significantly from its equilibrium rate. The proposed methodology concentrates on the statistical properties of the misalignment rate. Considering a Logistic Smooth Transition Autoregressive (LSTAR) model we test whether a nonlinear STAR model or a linear autoregressive model should be estimated. This test is applied to three Central & Eastern European Countries – members of the EU. In each case, we examine exchange rates per EURO to find whether these rates imply efficient foreign exchange markets. The contribution of this paper is twofold. Firstly, we find whether those countries' currencies are misaligned against EURO. This is an important information regarding their perspective membership of EMU. Secondly, this paper provides an appropriate framework of examining FOREX efficiency when a developing country is the case. To our knowledge of literature, this is the first time the concept of equilibrium exchange rate (BEER) is applied to characterize a foreign exchange market as efficient or inefficient.[4]

The structure of the paper is as follows. The model and the proposed test are described in the following section. Section 3 describes the dataset and section 4 presents our estimation. A final section summarizes and discusses the policy implications of this analysis. It is shown that there is a strong connection among equilibrium rates, market efficiency and currency crises. As a matter of fact, the issue of currency crises cannot be isolated from this of equilibrium exchange rates.

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explained by the relevant fundamentals. But, the estimation of the error correction model shows that exchange rate returns are predictable by the fundamentals. Therefore, the efficiency hypothesis is rejected.

[3] He assumes that FOREX efficiency requires that two spot rates cannot be cointegrated.

[4] A similar study is this of Aron (1997). However, our approach differs significantly from this. Our test does not require unpredictable exchange rates.

2. Theoretical Framework

2.1 The Model

Although the BEER approach does not rely on any theoretical model, here we apply a modification of the monetary model of exchange rate determination. Consider the Monetary model of exchange rate determination (Frenkel, 1976; Kouri, 1976 and Mussa, 1976 & 1979), in which prices are flexible and PPP & UIP conditions hold all the time. Assuming that agents form rational expectations, the monetary model can be expressed as following:

$$s_t = (m_t - m_t^*) - \phi(y_t - y_t^*) + \mu \Delta s_{t+1}^{\ e}$$

$$s_t = (m_t - m_t^*) - \phi(y_t - y_t^*) + \mu(E_t[s_{t+1}] - s_t)$$

$$s_t = \frac{1}{1+\mu}[(m_t - m_t^*) - \phi(y_t - y_t^*)] + \frac{\mu}{1+\mu} E_t[s_{t+1}] \qquad (1)$$

After n periods, equation (1) becomes:

$$s_t = \frac{1}{1+\mu} \sum_{i=0}^{n-1} \left(\frac{1}{1+\mu} \right)^i E_t[(m_{t+i} - m_{t+i}^*) - \phi(y_{t+i} - y_{t+i}^*)] + \left(\frac{\mu}{1+\mu} \right)^n E_t[s_{t+n}]$$

Assuming that $\lim_{n\to\infty} \left(\frac{\mu}{1+\mu} \right)^n E_t[s_{t+n}] = 0$, the above expression takes the form of:

$$s_t = \frac{1}{1+\mu} \sum_{0}^{\infty} \left(\frac{1}{1+\mu} \right)^i E_t[(m_{t+i} - m_{t+i}^*) - \phi(y_{t+i} - y_{t+i}^*)] \qquad (2)$$

Expression (2) implies that the exchange rate is forward looking and responds today to new information about future values of money stock and output.[5] In other words, current values of exchange rates contain expectations for future values of the fundamentals. If the foreign exchange market is efficient, current spot rates reflect all

[5] The effect on the exchange rate is discounted by the factor (1/1+μ). This means that the higher the expected future change in money and output differentials, the smaller the current effect on the exchange rate.

available information for current and future values. So, a misaligned spot rate may exist because of new or unexploited information. In that case, the foreign exchange market is inefficient.

Therefore, assuming that the BEER is estimated based on the fundamentals of the Monetary model (including the inflation rate)[6], if the current spot rate deviates significantly from its equilibrium rate, the foreign exchange market does not incorporate efficiently all available information. As a consequence, the market cannot be efficient.

Let now discuss the way the Behavioral Equilibrium Exchange Rate (Clark & MacDonald, 1998) is estimated. Focused on the above fundamentals, the long run exchange rate is estimated by the following equation:

$$s_t = (m_t - m_t^*) - \phi(y_t - y_t^*) + \mu(\pi_t - \pi_t^*) \quad (3)$$

where s = nominal exchange rate, m = money supply, y = output, π = inflation rate. The expected sign of the fundamentals is given by the corresponding signs in equation (3). Namely, a relatively higher increase in domestic money supply is expected to increase the exchange rate (i.e. to depreciate the domestic currency).[7] The same holds for the inflation rate differential. On the other hand, a relatively higher increase in domestic output is expected to appreciate the domestic currency.[8]

The estimated rate, implied by equation (3), corresponds to the long run exchange rate but not to the equilibrium rate. This rate will be estimated by capturing the sustainable values of the independent variables. Then, these values are included in equation (3), which has the following form:

$$BEER_t = (\tilde{m}_t - \tilde{m}_t^*) - \phi(\tilde{y}_t - \tilde{y}_t^*) + \mu(\tilde{\pi}_t - \tilde{\pi}_t^*) \quad (4)$$

[6] Here, we employ a modification of the monetary model. According to this model, the nominal exchange rate depends on the relative money supply, the relative output, and the interest rate differential. Applying the UIP condition and the PPP hypothesis, the exchange rate equation becomes: $s = (m - m^*) - \phi(y - y^*) + \mu(\pi^e - \pi^{e^*})$. Now, assuming that agents have perfect foresight, we derive equation (3).

[7] The increased money stock increases the domestic price level. This makes domestic goods less competitive than the foreign ones. Thus, demand for domestic goods decreases and this of foreign goods increases. As a result, the domestic currency depreciates.

[8] This will increase the demand for money and given the money supply constant, there is excess demand for the domestic money stock. The money market equilibrium will be restored if people reduce their expenditure on consumption. Domestic prices fall and through PPP the exchange rate decreases.

Comparing this rate with the actual exchange rate we find how the latter deviates from the former. In other words, this yields the misalignment rate, which shows whether the exchange rate is overvalued or undervalued. According to the specification of the monetary model, an increase in the exchange rate means depreciation of the domestic currency. Thus, if s > beer, the domestic currency is undervalued. In contrast, if s < beer, the domestic currency is overvalued.

2.2. Foreign Exchange Market Efficiency

In terms of foreign exchange market efficiency, the misalignment rate should not be significantly high. This requirement is sensible since a high misalignment rate implies that the actual exchange rate is not in line with the fundamentals. However, this is not sufficient. What we actually mean by "high misalignment"? Is this 5%; 10% or higher? Thus, we need a more specific criterion. This comes by the statistical analysis of the misalignment rate. More specifically, we need to know about the stationary nature of the misalignment rate. If this is non-stationary [i.e. I(1)], it implies that past values can predict future values. When a series follows a random walk, previous shocks can have a continuous impact on the current values of the series. As a consequence, the misalignment rate contains unexploited information which can be used for unusual profits. In other words, the available information is not efficiently exploited. In that case, the foreign exchange market is not efficient.

In contrast, an efficient foreign exchange market requires the misalignment rate to be stationary, i.e. I(0). This means that it contains no information. All the available information is incorporated by the BEER. Thus, the actual exchange rate is in line with the fundamentals. Under this circumstance, the foreign exchange market is efficient because it efficiently exploits all the available information. In other words, the stationary nature of the misalignment implies that the spot rate deviates from its equilibrium rate by only transitory components (i.e. it follows a white noise process). Under this circumstance the misalignment is mean reverting, indicating an equilibrium process.

The actual exchange rate may deviate from its equilibrium rate either because fundamentals are away from their sustainable values or because the foreign exchange

market is not properly working. What make macroeconomic fundamentals to move away from their equilibrium values may be transaction costs, government intervention and inefficient exploitation of the available information. MacDonald (1988) mentions some of the reasons of foreign exchange market inefficiency. For instance, transaction costs, government intervention and incomplete information are some of those. As a consequence, the concepts of equilibrium and efficiency are very closely related.

Obviously, the exchange rate should not be highly volatile. Exchange rate fluctuation is directly related with exchange rate misalignment. The latter is the core of future exchange rate fluctuation. If significant misalignments persist, the behavior of the exchange rate is expected to be unstable in its attempt to find its equilibrium rate. On the other hand, an observed exchange rate close to its equilibrium implies that we do not expect high fluctuations in the future, excluding unanticipated shocks. Therefore, foreign exchange market efficiency requires a stable and not misaligned spot rate.

Since our main concern is foreign exchange market efficiency, we need to know whether the spot rate moves self-directed toward to equilibrium or instead it is driven by government interventions. To capture this we employ official exchange rates as well as cross exchange rates. The latter is this exchange rate if any intervention is absent. In other words, triangular arbitrage is held perfectly. If the cross and the official rates are identical, the official spot rate is determined under no intervention. In contrast, if the official spot rate deviates significantly from the cross exchange rate, we imply that the monetary authorities intervene in the foreign exchange market to correct the disequilibrium. Strictly speaking, interventions are not consistent with efficiency. However, an intervention can drive the exchange rate closer to equilibrium. In other words, it may help the foreign exchange market to work efficiently. But, this may be misleading because any presence of intervention is evidence that the FOREX cannot efficiently exploit all the available information.

Moreover, the presence of structural breaks is very common in the case of developing countries. Changes in the monetary policy; exchange rate regime-switching and other structural reforms in these economies can affect exchange rate movements and as a consequence can interrupt the mean-reverting process of the misalignment rate. This implies that by taking into account these developments we may find a mean-reverting -

but interrupted for a short period – process. Therefore, if by excluding any break we reject the mean reverting process and by allowing the presence of a break we find that the misalignment follows a white noise process, the FOREX market is said to be "quasi-efficient". By this term we mean that a shock can cause market inefficiency only temporarily. While the mean reverting process is interrupted, this process is continued after a short period.

Finally, we examine whether the exchange rate misalignment is characterized by a nonlinear mean reverting process. Heckscher (1916) first introduced the idea that adjustments may be nonlinear because of transaction costs.[9] Nonlinearities are modeled by models that allow the autoregressive parameter to vary. These models are known as Threshold Autoregressive (TAR) models.[10] The TAR model allows for a transaction costs band within which no adjustment takes place. Outside the band, arbitrage becomes profitable and the process becomes stationary autoregressive. However, Taylor & Taylor (2004) mention that there is no unique transaction cost and this causes many threshold barriers. Michael et. al. (1997) and Taylor (2001) argue that Smooth Threshold Autoregressive -STAR- models (Granger & Terasvirta, 1993) are more appropriate than TAR, because adjustments are smooth and it is unlikely that agents' behavior change simultaneously. In these models, adjustments are smooth and in contrast to TAR models, they take place in every period (inside and outside the band). Hence, adjustments may be smooth rather than discrete.

Taylor et al (2001), among others, show that the speed of convergence to equilibrium is higher when deviations are large. This implies that the higher the misalignment is, the faster the mean reverting process becomes. Obstfeld & Taylor (1997) argue that this may be attributed to the higher arbitrage when the misalignment is high. Similarly, Lothian & Taylor (2004) find significant nonlinearities on US dollar/UK pound and US

[9] Other sources of nonlinearity, shown in the literature, are the heterogeneity of opinion in the foreign exchange market (Kilian & Taylor, 2003), Central Banks' policy (Taylor, 2004) and the differences in technology and preferences (O'Connell & Wei, 2002).

[10] Another set of nonlinear models implies that the autoregressive parameters are subject to Markov Regime-Switching (Hamilton, 1989). Kanas & Genius (2005), by applying a Markov volatility regime switching ADF test, find that the US/UK real exchange rate is stationary when the exchange rate is low volatile, and non-stationary when it is highly volatile. Bergman & Hansson (2005) find that six major currencies against US dollar are characterized by a 2-state Markov-Switching AR(1) model as the unique regime autoregressive model is rejected by the data.

dollar/French franc real exchange rates. A nonlinear ESTAR model implies that the speed of mean reversion is faster for larger shocks. In general, compared to a linear AR(1) model, the nonlinear model indicates that real exchange rates are moving faster toward to equilibrium.

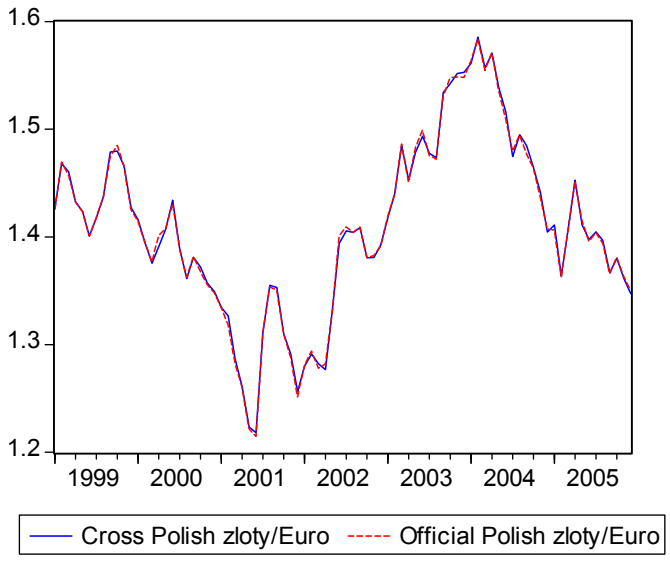
In line with recent empirical findings, in the empirical section of the present paper we test whether a linear autoregressive model or a nonlinear STAR model should be estimated.

3. Data

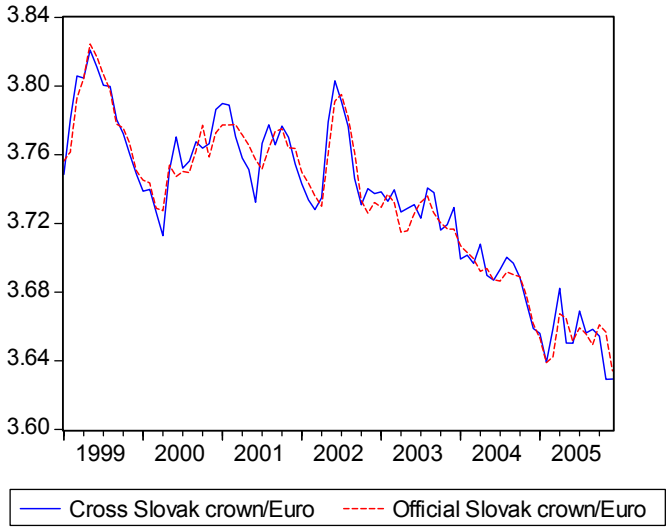
The data set, collected mainly from IFS CD-ROM (2006), consists of monthly observations on exchange rates, inflation rates, money supply and output, from 1999:1 to 2006:2, for Czech Republic; Slovak Republic; Poland and Euro Area.

Nominal exchange rates (s) stand for bilateral exchange rates per EURO. In each case we employ two different types of exchange rates. Official exchange rates per EURO are taken form those countries' Central Bank databases. The other type of exchange rates corresponds to cross exchange rates. They are computed through US dollar exchange rates assuming perfect triangular arbitrage. For instance, the Polish zloty/EURO exchange rate is estimated using the Polish zloty/US dollar and EURO/US dollar exchange rates. An increase in both types of exchange rates implies depreciation of the national currency against EURO.

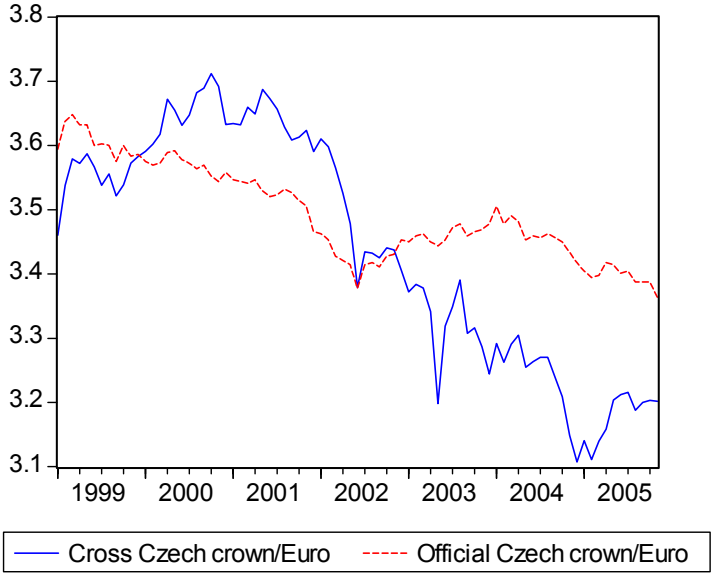
Graph 1: Polish zloty/Euro



Graph 2: Slovak crown/Euro



Graph 3: Czech crown/Euro



The above graphs plot official against cross exchange rates (both in natural logarithms). These rates are identical for the case of Polish zloty per Euro, while they are almost equal for the Slovak crown/Euro. This implies that spot rates against Euro are determined under no (or at least little) intervention in the foreign exchange market. In contrast, the official Czech crown/Euro differs significantly from the corresponding cross

exchange rate. The former is less volatile, which may be attributed to government interventions in the foreign exchange market.

Money supply (m) corresponds to change in money supply and it is presented as a percentage. Similarly, inflation rate (π) is based on the Consumer Price Index. Euro Area's inflation rate is computed as the average of the CPI-inflation rates of Germany; France; Italy and Spain. Finally, output variable (y) is represented by industrial production. Likewise, Euro Area's industrial production is the average of the corresponding values of Germany; France; Italy and Spain. All variables, apart from money supply and inflation rate, are presented in natural logarithms.

4. Empirical Analysis

4.1 Behavioral Equilibrium Exchange Rate

Estimation procedure is performed by the Johansen Cointegration Technique (Johansen, 1988). Under this framework, the fundamentals and the exchange rate must form a long-run linear combination. We start by regressing VAR models[11] in levels to select the appropriate lag length by the Akaike Information Criterion (AIC).[12] Next, including the implied number of lags, we estimate the corresponding VAR models in first differences and we check their robustness by testing their parameters constancy. The next table tests whether the VAR-residuals are normally distributed; homoskedastic and serially uncorrelated. Values presented first are test statistics, while values in parentheses are probabilities of accepting the null.

[11] Given that the official Czech crown/Euro is different from the cross exchange rate, we have to regress two VAR models for the case of Czech crown per Euro exchange rate. For the rest of the examined exchange rates, only one VAR model is estimated because cross and official exchange rates coincide.

[12] This statistic is given by $AIC = T \log|\Sigma| + 2N$, where T= number of observations, N = total number of parameters, and $|\Sigma|$ stands for the determinant of the variance/covariance matrix of the residuals. The appropriate lag length is this which "soaks up" autocorrelation. So, we select this number of lag which fits with the lowest value of the AIC statistic.

Table 1: Diagnostics

Model / **Null Hypothesis**	**Lags**	**No autocorrelation**	**Homoskedasticity**	**Normality**
Poland/Euro	9	9.42 (0.39)	327.6 (0.61)	*58.26 (0)*
Czech/Euro (official)	5	6.13 (0.72)	180.42 (0.71)	*40.47 (0.02)*
Czech/Euro (cross)	5	7.87 (0.54)	116.7 (0.01)	*101.4 (0)*
Slovak/Euro	8	24.4 (0.08)	663.7 (0.45)	*113.6 (0)*

The no-autocorrelation hypothesis is a Lagrange Multiplier test, while White's heteroskedasticity and Jarque-Bera (normality) test statistics follow the Chi-square distribution. There is strong evidence that errors are not serially correlated. Similarly, the evidence is strong against heteroskedasticity, apart form Czech/Euro (cross) model, in which there is weaker evidence. In contrast, normality can be accepted only in the Czech/Euro (official) model at the 1% significance level. However, this is not going to violate our estimation output. Since our data set is quite large (more than 80 observations), the errors are asymptotically normal (Central Limit Theorem). In overall, diagnostics imply that the corresponding VEC models do not suffer from any misspecification problem. Thus, robustness of our estimation is confirmed.

The acceptance of at least one cointegrating vector establishes a valid long run relationship between the exchange rate and the vector of fundamentals. In other words, this evidence implies that exchange rate movements are explained by the monetary fundamentals. Cointegration tests are presented in table 2. The second column of the table shows the variables included in the vector of fundamentals. At a first stage we include all variables in the vector. However, weak exogeneity is not accepted in some cases[13]. This may mean that some variables are endogenous to the exchange rate equation. To avoid this, we exclude those variables for the VECMs. So, industrial production and money supply differentials are found to be endogenous to the Poland/Euro and Czech/Euro, respectively. Only by accepting the weak exogeneity restriction, the implied cointegrating relationship is valid. This means that movements toward to equilibrium are due to exchange rate correction movements.

[13] These results are available on request.

Table 2: Cointegration – Weak Exogeneity

Model	Variables	Cointegration Sub-model	Number of C.V.		Weak Exog. test: LR statistic
			Trace	*Max Eig.*	
Poland/Euro	s, m, π	2nd	1	0	4.69 (0.09)
Czech/Euro (cross)	s, y, π	2nd	1	1	8.68 (0.01)
Czech/Euro (offic)	s, y, π	2nd	1	0	1.04 (0.59)
Slovak/Euro	s, m, y, π	2nd	1	1	1.42 (0.69)

Table 2 presents two cointegration test statistics, the trace and the max-eigenvalue. While the latter finds no evidence of cointegration in the Poland/Euro model, the former finds evidence of a unique cointegrating vector in each model. Hence, based on trace statistic, the fundamentals can explain exchange rate fluctuations. Furthermore, the acceptance of the weak exogeneity assumption validates the implied cointegrating relationships.

The estimated coefficients are presented in table 3. Values on the second column of the table correspond to the estimated adjustment coefficients. Since they are all statistically significant, these values show the speed of adjustment. For instance, misalignments are reduced by 12% in a month for the Poland/Euro exchange rate. Similarly, the cross and the official Czech/Euro exchange rates move closer to equilibrium - in a month - by about 25% and 8%, respectively. Stronger convergence to equilibrium is observed in the Slovak/Euro case. Exchange rate deviations from equilibrium damp out by 64% during a month.

Table 3: Adjustment Coefficient - Estimated Coefficients

Model	alpha (s.e.)	constant (s.e.)	m-m* (s.e.)	y-y* (s.e.)	π-π* (s.e.)
Poland/Euro	-0.12 (0.03)	1.31 (0.05)	0.02 (0.007)	----------	0.004 (0.007)
Czech/Euro (cross)	-0.25 (0.05)	3.61 (0.02)	----------	-1.36 (0.13)	0.02 (0.01)
Czech/Euro (official)	-0.08 (0.02)	3.57 (0.03)	----------	-0.78 (0.17)	-0.05 (0.01)
Slovak/Euro	-0.64 (0.13)	3.81 (0.01)	-0.0003 (0.0003)	-0.32 (0.05)	-0.006 (0.001)

The inflation rate differential (Poland/Euro) and the money supply differential (Slovak/Euro) are statistically insignificant. Therefore, they should be excluded from the foregoing analysis. When it comes to the sign of the estimated coefficients, money supply and output differentials are as expected. According to the monetary model of exchange rate determination, a higher increase in the domestic money supply depreciates the domestic currency. This is in line with the positive sign, shown in Poland/Euro exchange rate equation. Moreover, if the domestic country grows more than the foreign one, then we expect the domestic currency to appreciate. In our case, the negative sign of the industrial production differential is consistent with the above statement. However, the evidence is not clear for the inflation rate differential. This is correctly signed in the Poland/Euro and Czech/Euro (cross) models, while it has the opposite sign in the (official) Czech/Euro and Slovak/Euro models. A higher domestic inflation rate makes domestic goods less competitive than the foreign ones. Thus, demand for domestic goods decreases and this of foreign goods increases. As a result, the domestic currency depreciates.

4.1.1. Polish zloty per Euro Equilibrium Exchange Rate

The long run exchange rate equation, excluding any insignificant variables, is presented by the following equation:

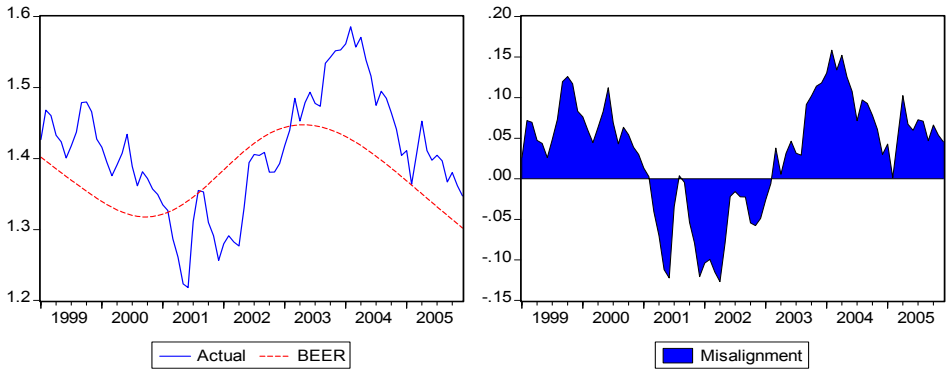
$$s = 1.31 + 0.02(m - m^*) \tag{5}$$

This rate corresponds to the current equilibrium exchange rate, while the deviation of this rate from the actual exchange rate stands for the current misalignment rate. However, what exactly matters is total misalignment. This is estimated only by estimating the behavioral equilibrium exchange rate. In this case, we get the smoothed value of the money supply differential by the Hodrick-Prescott (1997) filter.[14] Next, we replace, in

[14] This is a smoothing method, which estimates the long run components of the variables. Among others, Mise et. al. (2005), Kaiser & Maravall (1999) and Baxter and King (1999) provide evidence of suboptimal H-P filtering at the endpoints. To avoid this inconsistency, following Kaiser and Maravall (1999), we estimate optimal ARIMA forecasts and we apply the H-P filter to the extended series. This approach minimizes revision standard deviation (Mise et. al., 2005).

equation (5), its actual value by the smoothed one to get the BEER. This is shown in the following graph, plotted with the actual exchange rate.

Graph 4: Polish zloty/Euro



The left hand-side of the graph illustrates the above relationship, while the right hand-side shows the total misalignment rate. If the actual rate is higher than the BEER, the domestic currency is undervalued. This corresponds to positive misalignment values. In contrast, if the actual exchange rate is lower than the estimated BEER, the national currency is said to be overvalued. This is shown by negative misalignment values.

The evidence shows that the exchange rate is misaligned through time. There are two undervaluation eras and a unique overvaluation period for the Polish zloty. On average, the actual exchange rate deviates by about 4%. The highest misalignment rate (overvaluation by 10%) is observed in June 2001. At the end of the estimated period (December 2005), the Polish zloty was undervalued by 3%.

The observed exchange rate follows a downward path from 1999 to 2002, implying an appreciation trend for the Polish zloty. In contrast, the period 2002-2004 corresponds to a significant devaluation of the Polish zloty against Euro. Specifically, during this period, the Polish currency depreciated by 19% against Euro. This may be attributed to the failure of matching the inflation and interest rate targets. For the period 1999-2003, the inflation target was set to a rate less than 4%. However, in 2000 this target was re-set to 5.4%-6.8%. In 2001, the inflation target was 6%-8%, but it was not fulfilled because of supply shocks. During the estimated period, the long-term interest rate was decreasing but slightly above the reference rate. It is worth notable that during this period, the depreciation trend was consistent with the estimated BEER. In other words, the BEER

was increasing as well. However, the fluctuation was smoother and the devaluation period was shorter. On the other hand, the BEER implied even more higher exchange rate. This means that the Polish zloty was overvalued.

The BEER follows a downward path from 2003, while the actual exchange rate starts decreasing from 2004. Namely, the appreciation trend for the Polish zloty delayed by a year. Furthermore, BEER implies that during the period 2003-2005 the Polish zloty was undervalued. The zloty's appreciation trend is the outcome of a tight monetary policy, applied by the Polish monetary authorities.

4.1.2. Czech Crown per Euro Equilibrium Exchange Rate

The current equilibrium of the cross exchange rate is given by the following equation:

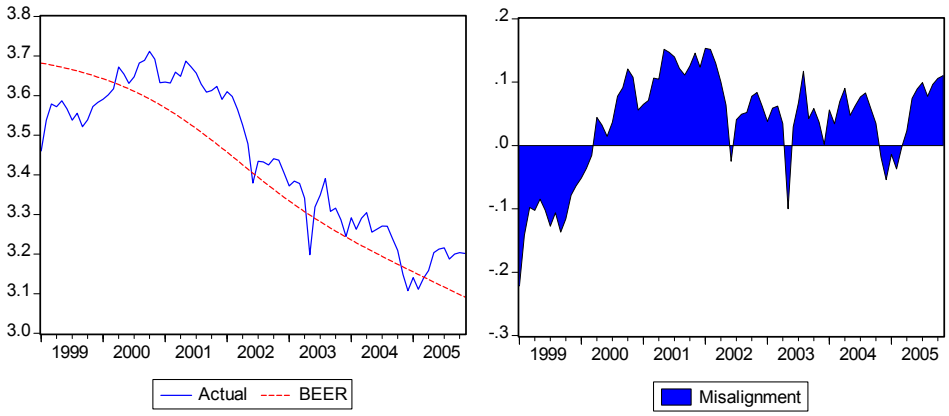
$$s = 3.61 - 1.36(y - y^*) + 0.02(\pi - \pi^*) \quad (6)$$

Similarly, the current equilibrium of the official exchange rate is given by equation (7):

$$s = 3.57 - 0.78(y - y^*) - 0.05(\pi - \pi^*) \quad (7)$$

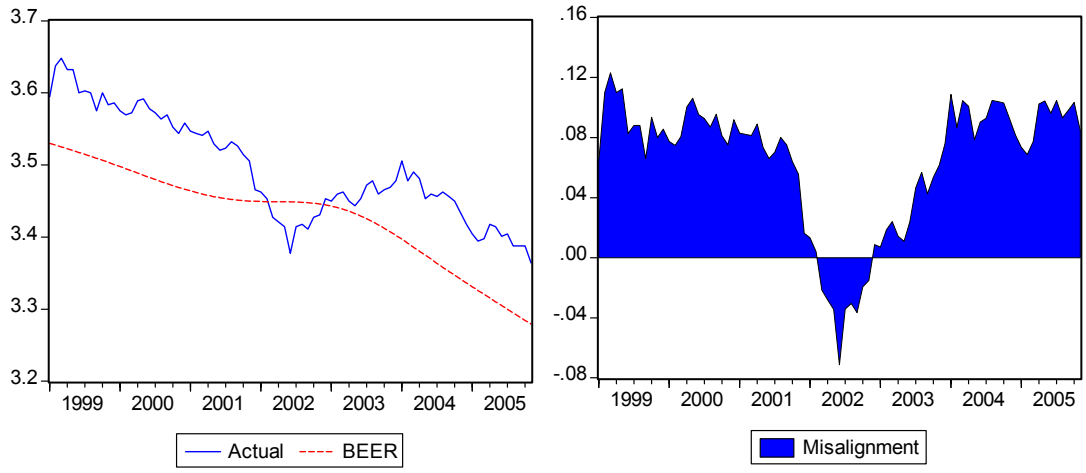
Then, by applying the modified Hodrick-Prescott filter, we estimate the sustainable values of the fundamentals. The smoothed values substitute their actual values, in equations 6 and 7, to get the Behavioral Equilibrium Exchange Rate. By subtracting this rate from the actual exchange rate, we derive the total misalignment rate. These rates are shown below:

Graph 5: Cross Czech crown/Euro



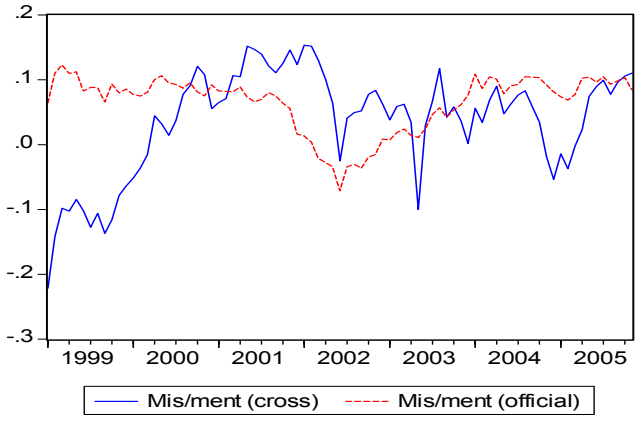
Starting with the cross exchange rate, Czech crown was mainly undervalued against Euro. However, the beginning of the estimated period is an overvaluation period which lasts until 2000. The highest misalignment rate (overvaluation by 6%) is observed in January 1999. On average, the exchange rate is misaligned by 2%, while at the end of the estimated period the Czech crown was undervalued against Euro by 3%.

Graph 6: Official Czech crown/Euro



Now turning to the official exchange rate we can see from graph 6 that BEER implies a lower exchange rate. Namely, there is evidence that the Czech crown was mainly undervalued, except a single overvaluation period during 2002. In overall, this is not contradictory to the above implication (based on cross exchange rate analysis). But, as exchange rates are different, equilibrium exchange rates are different as well. As a consequence, the implied misalignment rates are not equal. This is shown in the following figure:

Graph 7: Comparing the Misalignment Rates



Specifically, the misalignment rate based on cross exchange rate is more volatile and higher than the other one. When overvaluation is the case the highest (cross) misalignment rate is 6.5%, while the corresponding (official) misalignment rate is 2%. In the case of undervaluation, the cross and official misalignment rates mention undervaluation by 4% and 3%, respectively. However, on average the two misalignment rates are equal (about 2%). All these imply that foreign exchange interventions have driven the exchange rate closer to equilibrium.

In 1997 Czech Republic abandoned the fixed peg exchange rate regime. Since then, the Czech crown is determined under a managed floating exchange rate regime. This means that although the currency can fluctuate, the Central Bank retains the right of intervention in the foreign exchange market. In most of the estimated period the Czech crown appreciates against Euro. This is a natural consequence of the evolutionary process of the Czech economy. In 2004, the Czech economy grew by 4% - the same rate as in 2003 – which was higher than the average GDP growth rate of the former EU members.

The appreciation trend of the Czech crown is in line with the macroeconomic developments. In other words, the BEER – estimated by the macroeconomic fundamentals – establishes the appreciation of the Czech currency. Thus, this can be characterized as an equilibrium movement.[15] The Czech inflation rate follows a downward path. In 1997 the inflation rate was 8%, while in 2004 prices were higher by only 1.8% - compared to 2003 – which was lower than the reference rate (2.4%). The lower inflation rate and in general the increased credibility of the national monetary system, helped the long term interest rate to follow a decreasing trend as well. During the period 2003-2004, the Czech interest rate was 4.7%, lower than the reference rate (6.4%).

In terms of its fiscal discipline, the government deficit as a ratio of GDP was 12.6% in 2003. Specifically, this rate increased by 5.8% relative to the previous year. In contrast, public debt as a ratio of GDP was 37.8% in 2003 (i.e. lower than 60%). However, this rate was increased by 9% compared to 2002. These developments may

[15] Though, the depreciation of the cross and official Czech crown during 2003 and 2002-2004, respectively, was not in line with the BEER. In other words, the fundamentals included in the BEER equation do not dictate this movement. This can be explained by other macroeconomic conditions, shown in few lines below.

explain the depreciation of the Czech crown against Euro during 2003 (cross) and for the period 2002-2004 (official).

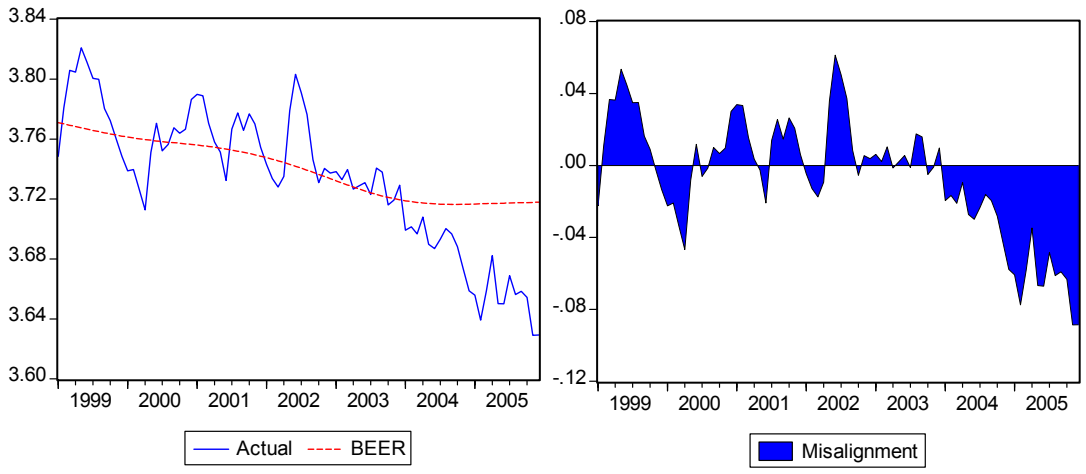
4.1.3. Slovak Crown per Euro Equilibrium Exchange Rate

Similarly, the long run exchange rate equation is given by:

$$s = 3.81 - 0.32(y - y^*) - 0.006(\pi - \pi^*) \qquad (8)$$

Then, we estimate the sustainable values of the output and inflation rate differentials, applying the modified H-P filter. The actual values of the fundamentals are substituted by their smoothed series. As a consequence, equation (8) becomes the Behavioural Equilibrium Exchange Rate equation. Total misalignment is the difference of the actual exchange rate from the estimated BEER. These rates are shown in the following graph.

Graph 8: Slovak crown/Euro



The actual exchange rate fluctuates around BEER, indicating small in duration and value misalignment rates. Namely, the Slovak crown was both slightly overvalued and undervalued against Euro. On average, the exchange rate is misaligned by less than 1% (0.7%). The highest misalignment rate is observed at the end of the estimated period. While the BEER implies a stable exchange rate, the domestic currency follows an

appreciation trend. This yields the overvaluation of the Slovak crown by 2% (December 2005).

The estimated period can be decomposed into two periods. The first one starts in 1999 and ends in 2004, while the other starts in 2004 and lasts until the end of the estimation period. The former period corresponds to a small and controlled appreciation trend for the Slovak Crown, while during the latter period the Slovak currency appreciates rapidly. The appreciation trend - during the first period - is consistent with the fundamentals, since the BEER follows the same trend. After a year of the creation of the Slovak Republic (1993) GDP increased by 4.3%, while at the same time inflation rate decreased from 20% to 12%. In 2003, the Slovak economy grows by 4.5% and in 2004 grows by 5.5%. When it comes to the inflation rate, this was 5,9% in December 2004, lower by 3.4% compared to 2003. This is still higher than the reference rate, but it follows a declining trend.

On the other hand, the long-term interest rate is lower than the reference rate. Similarly, Slovak Republic has a well-specified public finance position, since the public debt criterion is already fulfilled and the government deficit criterion is expected to be fulfilled by 2007. A question arises is why the exchange rate falls rapidly after 2004. This movement is not dictated by the fundamentals, since in the second period the BEER implies a stable exchange rate. The true reason is the exchange rate regime switch. The Slovak crown is determined under a floating exchange rate regime since 2004. However, the National Bank of Slovakia retains the right of intervention in the foreign exchange market to manage the exchange rate fluctuations. This means that although the BEER was able to capture all the previous positive facts of the Slovak economy, these facts seem to be discounted by delay (retroaction) during the free float era or at least they create favorable expectations for the Slovak economy.

4.2. Foreign Exchange Market Efficiency

As mentioned earlier, the efficiency market hypothesis is tested through examining the stationary nature of the misalignment series. Here we relax the linearity hypothesis and we test whether the misalignment exhibits a nonlinear behavior. This test is pivotal

for the validity of our analysis. If a series follows a nonlinear adjustment, the autoregressive parameter will be biased upward and the unit root test will be biased against rejecting nonstationarity. Next, we present an LSTAR model and we examine whether this or a linear autoregressive model should be estimated.

4.2.1 Testing Linearity Hypothesis

Following Terasvirta (1994) we consider a Logistic Smooth Transition Autoregressive (LSTAR) model of order p for the misalignment series (ξ).[16]

$$\xi_t = \pi_{10} + \pi_1' w_t + (\pi_{20} + \pi_2' w_t) \cdot [(1 + \exp\{-\gamma(\xi_{t-d} - c)\})^{-1} - 0.5] + u_t \quad (9)$$

$$u_t \sim NID(0, \sigma_u^2)$$
$$\pi_j = (\pi_{j1}, ..., \pi_{jp})^{-1}, j = 1, 2$$
$$w_t = (\xi_{t-1}, ..., \xi_{t-p})^{-1}$$
$$\gamma > 0$$

The term $(1 + \exp\{-\gamma(\xi_{t-d} - c)\})^{-1}$ stands for the transition function while d is the delay parameter which presents the possibility that the FOREX market will react to deviations from equilibrium with a delay. The parameter γ determines the speed of the transition process between the upper and the bottom regimes. The process becomes linear when the transition function is equal to zero. That means that linearity is confirmed if the null hypothesis H_0: γ = 0 is accepted against the alternative H_1: γ > 0. Expression (9) can be estimated only under the alternative hypothesis because the parameters c, π_{20} and π_2' can take any value. The Lagrange Multiplier test statistic has an asymptotic Chi-square distribution under the null, but the distribution is dependent on π. Davies (1977) suggests an alternative LM test statistic which has an unknown distribution under the null. Furthermore, in order to avoid any lack of power of the proposed LM test statistic, Luukkonen et al (1988) replace the transition function in equation (9) with its third-order

[16] Actually, Terasvirta (1994) considers a Logistic Smooth Transition (LSTAR) model as well as an Exponential Smooth Transition (ESTAR) model and proposes a test procedure to choose between those models.

Taylor approximation. Terasvirta (1994) tests linearity against LSTAR or ESTAR by estimating the following expression:

$$\xi_t = \beta_{00} + \sum_{j=1}^{p} \beta_{0j}\xi_{t-j} + \sum_{j=1}^{p} \beta_{1j}\xi_{t-j}\xi_{t-d} + \sum_{j=1}^{p} \beta_{2j}\xi_{t-j}\xi_{t-d}^2 + \sum_{j=1}^{p} \beta_{3j}\xi_{t-j}\xi_{t-d}^3 + e_t \quad (10)$$

The null hypothesis of linearity is tested by $H_0 : \beta_{1j} = \beta_{2j} = \beta_{3j} = 0$, j = 1,…..,p., against the alternative that the null is not valid. Here we perform an F test as an approximation of the LM test. This approach has been undertaken by Michael et al (1997) in order to increase the power of the test. Harvey (1990) shows that when the lag length is large and the number of observations is small, the LM test suffers from low power. Terasvirta (1994) argues than in those cases LM-type tests should be avoided.

The estimation procedure begins with selecting the appropriate length of the autoregression of the misalignment series. This information is derived based on the Akaike Information Criterion (AIC) which suggests 5 lags for the Slovak misalignment, 4 lags for the cross exchange rate – based Czech misalignment, 1 lag for the official exchange rate – based Czech misalignment and 2 lags for the Polish misalignment. Once the order of the autoregression has been identified, the null hypothesis of linearity is tested for different values of the delay parameter. Tsay (1989) determines the parameter d which corresponds to the lowest p-value of the linearity test. Hence, we allow d to take values between 1 and 4 and we select this value of d such that the p-value of the F-type linearity test is minimized. The test is performed in RATS econometric software package using Doan's procedure.

Table 4: Linearity Test

Misalignment	p	d	F-statistic	Probability
Slovak	5	3	0.98	0.47
Czech(cross)	4	1	1.85	0.06
Czech(official)	1	2	2.11	0.10
Polish	2	2	2.06	0.07

The results imply that the linearity hypothesis is strongly accepted for the Slovak and Czech (official-based) misalignment rates, while the Polish and the Czech (cross-based) misalignment series follow a linear autoregressive process at 5% significance level. Since these series do not exhibit any nonlinear behavior we should not estimate an LSTAR model. Instead, we can get valid implications based on linear unit root tests such as the Augmented Dickey-Fuller test.

4.2.3. Linear Unit Root Tests

Given that different tests may provide different results, we employ three alternative procedures to test for misalignment stationarity. To confirm robustness we perform two tests in which the null states that the series is non-stationary (ADF, PP) and a test with the opposite null hypothesis (KPSS). A table summarizes these results at 5% and 10% significance level.[17]

Table 5: Unit Root Tests

Misalignment	ADF	PP	KPSS
Poland/Euro	I(0) I(0)	I(1) I(0)	I(0) I(0)
Czech/Euro (cross)	I(0) I(0)	I(0) I(0)	I(1) I(0)
Czech/Euro (official)	I(1) I(1)	I(1) I(1)	I(0) I(0)
Slovak/Euro	I(1) I(1)	I(1) I(1)	I(1) I(1)

first row: 5% significance level
second row: 10% significance level

Although at 5% significance level the three tests do not provide identical results, the evidence is more clear at 10% significance level. So, the misalignment in the Poland/Euro model is covariance stationary, i.e. I(0), while the exchange rate misalignment of the Slovak/Euro model is non-stationary, i.e. I(1). These results imply that the former misalignment is mean reverting but the latter follows a random walk. As a

[17] Test statistics, critical values and more information about the properties of the applied tests are available on the appendix section.

consequence, the Slovak/Euro FOREX market is not efficient because the misalignment contains information, not relevant with the estimated equilibrium exchange rate. On the other hand, the Poland/Euro FOREX market can be characterized as efficient because the misalignment contains no information useful for predicting its future value. As a result, all available information is relevant with the estimated BEER. In other words, the market exploits efficiently all the available information.

When it comes to the Czech/Euro FOREX market, the results based on the official exchange rate imply that this market is not efficient as the misalignment rate follows a random walk. On the other hand, the analysis based on cross exchange rate implies an efficient foreign exchange market. However, only the official exchange rate matters. As a matter of fact, this FOREX market is inefficient because of the government intervention. Although, these interventions help the exchange rate to move closer to the equilibrium rate, these are also the true reason for the implied inefficiency. Speculators with perfect foresight can predict the response of the monetary authorities. Thus, this is an information, not relevant with the macroeconomic fundamentals, which can be used by economic agents. Recall that in the previous section we saw that the cross exchange rate implies a higher misalignment rate than the official one does. So, we would expect inefficiency when the cross exchange rate is the case. This finding enforces the idea that the magnitude of exchange rate misalignment is not the only factor that matters for FOREX efficiency. Another important implication is that any kind of intervention in the foreign exchange market is contradictory to the FOREX efficiency.

4.2.4. Unit Root Tests and Structural Breaks

Even though nonlinearities in the form of multiple thresholds have been rejected, a single structural break may exist in the examined non-stationary misalignment series. Under the presence of structural breaks conventional unit root tests are biased against rejecting non-stationarity. For this reason we apply Perron's (1997) unit root test, which allows the presence of a single break to the misalignment process. The methodology is

based upon Perron (1997).[18] Perron (1989) presents three alternative break specification models. The first model, named "Innovational Outlier Model 1", allows only a change in the intercept under both the null and the alternative hypotheses. It has the following form:

$$\xi_t = \mu + \theta DU_t + \beta t + \delta D(T_b)_t + \alpha \cdot \xi_{t-1} + \sum_{i=1}^{k} c_i \Delta \xi_{t-i} + e_t \quad (11)$$

where ξ is the misalignment series, μ is a constant, DU is a dummy variable which captures the effect on the misalignment when the break occurs, t is a time trend and $D(T_b)$ is a dummy variable which captures the effect on the α-coefficient when the break occurs. The term $\sum_{i=1}^{k} c_i \Delta \xi_{t-i}$ is included in order to "soak up" autocorrelation. The second model, "Innovational Outlier Model 2", allows for both a change in the intercept and the slope at time T_b and has the following form:

$$\xi_t = \mu + \theta DU_t + \beta t + \gamma DT_t + \delta D(T_b)_t + \alpha \cdot \xi_{t-1} + \sum_{i=1}^{k} c_i \Delta \xi_{t-i} + e_t \quad (12)$$

where the dummy DT captures the change in the slope. The third model, "Additive Outlier Model", allows a change in the slope but both segments of the trend function are joined at the time of break. Firstly, the series are de-trended by the regression (13), and finally the test is performed in regression (14)

$$\xi_t = \mu + \beta t + \gamma DT^* + \tilde{\xi}_t \quad (13)$$

$$\tilde{\xi}_t = \alpha \cdot \tilde{\xi}_{t-1} + \sum_{i=1}^{k} c_i \Delta \tilde{\xi}_{t-i} + e_t \quad (14)$$

The main advantage of the Perron (1997) unit root test is that both the time of the break and the k-lag length are treated as unknown. These are identified endogenously to the system. The k-lag length is selected by the "general to specific" procedure instead of any information criteria, such as Akaike and Schwarz. When it comes to the selection of the break date, there are two alternative methods. First, T_b is selected as the value which minimizes the t-statistic for testing α=1. Secondly, T_b is this value which minimizes

[18] This test has its origins in Perron (1989). The present test differs from the Perron (1989) in the way the break point is determined. In Perron (1989), the break point was set exogenously. On the contrary, Perron (1997) test determines the break point endogenously.

either the t-statistic on the parameter associated with the change in the intercept (IO1 model), or the t-statistic on the change in the slope (IO2 & AO models). In the present paper we perform this test by the Colletaz & Serranito (1998) procedure for RATS. While the k-lag length is selected by the general to specific method, the break date is selected by minimizing the t_α-statistic.

Next, we test whether the non-stationary nature of the misalignment is described by a constant non-stationary process or by a stationary, but interrupted, process. In other words, we test stationarity in the presence of possible structural breaks. The following table presents the results by the Perron (1997) unit root test.

Table 6: Unit Root Test with Structural Breaks

Misalignment	Model	Break Time	k	μ	β	γ	α	t_a
Czech/Euro (official)	AO	2001:12	5	0.13	-0.003	0.005	0.86	-2.50
				(12.73)	(-8.13)	(8.53)	(16.00)	
Slovak/Euro	AO	2003:05	3	0.008	5.15	-0.003	0.47	-5.41**
				(1.70)	(0.34)	(-7.57)	(4.80)	

** means rejection of the null at 5% significance level.
t-statistics in parentheses.

The specification of this test is the Additive Outlier model, which allows a change in the slope. The date of the structural break in the two misalignment series is linked with the rapid appreciation of the domestic currencies. In the case of the Czech/Euro exchange rate, the appreciation of the Czech crown at the end of 2001 was consistent with the equilibrium rate but not in that magnitude. Furthermore, the appreciation of the Slovak crown in 2003 was not consistent with the macroeconomic fundamentals, since the BEER implies a stable exchange rate. When it comes to the unit root test, the Czech/Euro misalignment is still non-stationary even by allowing the presence of the break. In contrast, the Slovak/Euro misalignment is found to be stationary when the break is considered. These findings imply that the Czech/Euro (official) FOREX market is not efficient, while the Slovak/Euro market is "quasi-efficient".

5. Conclusion

The Forward Rate Unbiasedness Hypothesis (FRUH), as an instrument of testing foreign exchange market efficiency, is appropriate only when developed countries are examined. Even if forward markets in developing countries exist, forward rates may be highly regulated by governments. This is because many developing countries have not well-developed and independent from the government financial systems. As a matter of fact, we cannot rely on forward rates in order to make valid implications on FOREX market efficiency. Here we propose a test procedure based on equilibrium exchange rates, i.e. Behavioral Equilibrium Exchange Rate (BEER). An efficient FOREX market requires the exchange rate (spot rate) not to be highly unstable and misaligned and to deviate from its equilibrium rate by only transitory components. The statistical sense of this final requirement is that the misalignment should follow a white noise process.

Based on BEER analysis, on average the Polish zloty/Euro exchange rate is away from its equilibrium rate by 4%, the Czech crown/Euro exchange rate deviates by 2%, while the Slovak crown/Euro exchange rate is misaligned by less than 1%. These estimates provide positive implications regarding the low misalignment condition. However, the magnitude of the misalignment cannot be alone a useful tool. According to the proposed methodology, the misalignment should be characterized by a stationary mean-reverting process. Considering an LSTAR model we find no evidence of nonlinear adjustment in the examined series. So, linear unit root tests imply that the Poland/Euro FOREX market is efficient, the Czech/Euro FOREX market[19] is not, while the Slovak/Euro FOREX market is quasi-efficient. This implies that the latter misalignment is characterized by a stationary process, interrupted by a structural break.

A question arises is whether the monetary authorities should respond to the inefficiency of the foreign exchange market. In other words, what are the policy implications by this analysis? Should the Central Bank leave the market alone to be driven to equilibrium by its own forces or it should intervene to correct any misalignments. In terms of foreign exchange market efficiency, any government

[19] It is worth notable that the Czech/Euro market is inefficient when the official exchange rate is applied. In contrast, when the cross exchange rate is applied, the misalignment rate is stationary, which implies an efficient FOREX market. The implication of this finding has been discussed in the previous section.

intervention is a sign as well as a source of inefficiency. But, by intervening in the FOREX market, the exchange rate is driven closer to its equilibrium. We saw in the case of Czech/Euro exchange rate that a lower misalignment rate (manipulated by the monetary authorities) does not necessarily imply efficiency. But, what we actually desire more, a misaligned self-driven exchange rate (consistent with efficiency) or a manipulated equilibrium exchange rate (inconsistent with efficiency)? This is a dilemma because a misaligned exchange rate can create a competitiveness problem (when overvaluation is the case) or inflationary pressures (when undervaluation is the case). On the other hand, government interventions can be seen by speculators as evidence of inefficiency. When a market is inefficient there is room for speculative attacks, which may lead to a currency crisis.[20]

It seems sensible that we cannot provide a unique answer. The response of the Central Bank should be subject to the specific conditions of the market as well as to the nature of the exchange rate misalignment. In other words, if the possibility of speculative attacks is high, they should avoid any kind of intervention. But how can we figure out if a currency crisis is possible to occur? We have to examine a number of economic conditions in the domestic economy, such as macroeconomic fundamentals' performance; monetary and fiscal position; financial sector's stability and political situation. Economic performance is poor before crises. Moreover, there is a bi-directional relation between banking and currency crises. (Kaminsky & Reinhart, 1999). Namely, financial instability can import problems to the foreign exchange market. Finally, political situation is an important factor for crises. The empirical evidence shows that speculative attacks are more possible to succeed in countries with unstable political systems (Eichengreen et al, 1996). In addition, although fiscal situation is not directly linked with currency crises (only money-financed deficits are sources of speculative attacks); the evidence shows that some times it is related with attacks. This is because governments apply expansionary fiscal policies to reduce political cost.

[20] Krugman (1979) shows that if the Central Bank prevents its currency from depreciation, at some time there is loss of foreign exchange reserves. When appreciation is prevented, Central Bank's actions may increase inflation more than expected. When the authorities stop defending the currency, because of the above restrictions, successful speculative attacks are more possible. This pressure can lead to a currency crisis.

This study stresses the strong linkages among equilibrium exchange rates, market efficiency and currency crises. When it comes to examined foreign exchange markets, two of them are found to be efficient. That's means that no government intervention is needed. On the other hand, the Czech/Euro FOREX market is found to be inefficient. Given that Czech Republic performs successful economic and political reforms, combined with a tight monetary policy (inflation and interest rates are decreasing over time), we can argue that a controlled and moderate intervention will not be so dangerous for the domestic currency. However, a more careful examination is required, which is left for a future study.

APPENDIX

Table 1: ADF; PP & KPSS Unit Root Tests

Misalignment	Augmented Dickey-Fuller		Phillips-Perron		KPSS	
	Exogenous Term (lags)	Statistic (probability)	Exogenous Term (bandwidth)	Statistic (probability)	Exogenous Term (bandwidth)	LM Statistic
Poland/EURO (levels)	none (1)	-2.06 (0.03)	none (3)	-1.75 (0.07)	constant (6)	0.24***
Poland/EURO (1st dif)	none (0)	-7.77 (0.00)	none (7)	-7.76 (0.00)	----------	----------
(cross) Czech/EURO (levels)	none (0)	-2.60 (0.00)	none (2)	-2.60 (0.00)	constant (6)	0.39**
(official) Czech/EURO (levels)	none (0)	-0.74 (0.39)	none (4)	-0.75 (0.38)	constant (6)	0.23***
(official) Czech/EURO (1st dif)	none (0)	-10.07 (0.0)	none (4)	-10.00 (0.00)	----------	----------
Slovak/EURO (levels)	none (4)	-0.73 (0.39)	none (2)	-1.55 (0.11)	c + t (6)	0.229
Slovak/EURO (1st dif)	none (4)	-5.54 (0.00)	none (1)	-8.27 (0.00)	constant (0)	0.156***

Notes:
1. The null under the ADF and the PP tests assume that the series is not stationary. The null under the KPSS test assumes that the series is stationary.
2. MacKinnon (1996) one-sided p-values are shown in parentheses.
3. * means acceptance of the null at 1% significance level.
4. ** means acceptance of the null at 5% significance level.
5. *** means acceptance of the null at 10% significance level.

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