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Jörg Rahn

Bilateral equilibrium exchange rates of EU accession countries against the euro

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BOFIT Discussion Papers
Editor-in-Chief Iikka Korhonen

BOFIT Discussion Papers 11/2003

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Bilateral equilibrium exchange rates of EU accession countries against the euro

ISBN 951-686-870-3 (print)
ISSN 1456-4564 (print)

ISBN 951-686-871-1 (online)
ISSN 1456-5889 (online)

Suomen Pankin monistuskeskus
Helsinki 2003

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All opinions expressed are those of the authors and do not necessarily reflect the views of the Bank of Finland.

Jörg Rahn*

Bilaterial equilibrium exchange rates of EU accession countries against the euro

Abstract

We apply BEER and PEER approaches to calculate real equilibrium exchange rates for five EU accession countries in central and east Europe. Bilateral nominal equilibrium exchange rates against the euro are obtained through algebraic transformation of the results. Panel cointegration techniques are used to check the adequacy of the empirical model. The results reveal substantial overvaluations of the real exchange rate in several EU accession countries. Overvaluation is even higher when these exchange rates are expressed in nominal terms against the euro.

Keywords: Real Exchange Rates, Equilibrium Exchange Rates, Transition Economies, Panel Cointegration

JEL Classification: F31, F41, C23

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Jörg Rahn

Bilaterial equilibrium exchange rates of EU accession countries against the euro

Tiivistelmä

Tutkimuksessa lasketaan viiden tulevan EU-jäsenmaan reaalisia tasapainovaluuttakursseja kahdella eri menetelmällä. Tasapainovaluuttakurssit euroon nähden voidaan laskea näiden tulosten yksinkertaisella algebrallisella muunnoksella. Tulosten pätevystestataan paneeliyhteisintegroituvuusmenetelmällä. Tulosten mukaan reaaliset valuuttakurssit ovat yliarvostettuja useissa tulevissa EU-jäsenmaissa. Yliarvostus on vielä suurempaa nimellisiä valuuttakursseja käytettäessä.

Asiasanat: reaalinen valuuttakurssi, tasapainovaluuttakurssi, siirtymätaloudet, paneeliyhteisintegroituvuus

JEL-luokitusnumerot: F31, F41, C23

1 Introduction

The European Union will expand to 25 members on May 1, 2004. Among the new entrants are the former Comecon members Poland, Hungary, Slovenia, Estonia, Lithuania, Latvia, Slovakia and the Czech Republic. For these countries, accession implies a tighter linking of the new members' local currencies to the euro through participation in the European Exchange Rate Mechanism 2 system (ERM2), under which these local currencies will be allowed to fluctuate by ± 15 % around a fixed reference rate against the euro.[1] The fixing of the reference rate has profound economic implications for the new members. On one hand, if the selected exchange rate too high, the new member harms its export sector and faces a lack of competitiveness against imports by making its domestic goods comparatively expensive. A gross overvaluation leaves the country vulnerable to speculative attacks and exchange rate crises. Moreover, a subsequent lowering of the reference rate during participation in the ERM2 system would also most likely impede the country's entry into European Monetary Union (EMU). On the other hand, a reference rate below the equilibrium value unnecessarily reduces national wealth and prolongs the country's convergence towards Western European economic standards.

New members must participate in ERM2 at least two years before they can enter EMU, which is also conditioned upon meeting the Maastricht criteria. If past experience is any guide, the selected reference rates are likely to become the official fixed conversion rates against the euro at the time of entry. Give these implications, it is not premature to consider what the appropriate reference rates for central and east European countries (CEECs) should be if these new EU entrants are to avoid economic distortions.

Determination of an exchange rate that is neither undervalued nor overvalued raises the issue of equilibrium exchange rates. This area of research has witnessed major strides in recent years; fairly sophisticated methods that go well beyond traditional purchasing power parity (PPP) models are now available for calculating equilibrium exchange rates. These newer approaches have typically been applied to the euro, the dollar or the exchange rates of other Western industrialized countries. Only recently, however, few papers deal specifically with equilibrium exchange rates of transition economies.

The studies on transition economies can be distinguished between "out of sample" or "in sample" estimates. "Out of sample" means that equilibrium exchange rates are first estimated for non-transition economies. The resulting equation linking the real exchange rate to a set of fundamentals is then used to determine equilibrium exchange rates for transition countries. This procedure is particularly useful at the beginning of the transition process, when time series are too short for direct estimation.[2] "In sample," on the other hand, means that equilibrium real exchange rates for transition countries in the sample are estimated directly. Besides a number of estimations for individual countries,[3] there are

[1] Currently, a narrow band of 2.25 % either side of the central parity is under discussion (Economist, 2003). Such a tight link of the Eastern European exchange rates against the euro further raises the importance of choosing an appropriate reference rate.

[2] Examples of this approach are found in Halpern and Wyplosz (1996), Krajnyák and Zettelmeyer (1997) or Begg et al. (1999). In these papers, US dollar wages in non-transition countries are regressed on a set of variables. The coefficients obtained from these regressions are then taken to calculate equilibrium exchange rates for transition economies. Kim and Korhonen (2002) use dynamic heterogeneous panel models to derive equilibrium real exchange rates for a sample of middle and high-income countries and apply the coefficient estimates to compute real equilibrium exchange rates for transition countries.

[3] See Smidkova (1998), Filipozzi (2000) or Kemme and Tang (2000).

comprehensive studies of Maurin (2001), De Broeck and Sløk (2001) and Deutsche Bundesbank (2002). All these works, however, focus solely on the determination of economic fundamentals influencing the real exchange rate, i.e. quantitative estimates of real exchange rate misalignments are not presented. The exception is Égert (2002), who estimates real exchange rate deviations from equilibrium for five Central European transition economies against a basket of the German mark and the US dollar using a three-equation cointegration system.

Here, we take quarterly data ranging from the beginning of transition in the early 1990s to the first quarter of 2002 to compute real effective exchange rates based on trade weights for a broad set of countries. Equilibrium real exchange rates for five CEEC candidates are then determined by two different approaches, namely the behavioural equilibrium exchange rate (BEER) and the permanent equilibrium exchange rate (PEER). We also contribute to the literature by applying an algebraic transformation to extract bilateral nominal equilibrium exchange rates against the euro that allows us to directly assess possible reference rates for ERM2 participation. We apply panel estimation techniques to check for robustness and adequacy of our empirical model.

The paper is structured as follows. In section 2, we discuss the above-mentioned approaches to calculating equilibrium exchange rates. Section 3 describes the data for the subsequent empirical analysis and section 4 presents the results. Panel estimation techniques are presented and used to qualitatively check the previous results in section 5. The final section summarises our findings and offers some implications for economic policy.

2 Approaches to calculating equilibrium exchange rates

2.1 Behavioural equilibrium exchange rates

The most widely applied approach to calculating equilibrium exchange rates is purchasing power parity (PPP), which implies a constant real exchange rate over time. Empirically, however, it has been difficult to support the PPP hypothesis and observations of strong movements in real exchange rates have led to alternative concepts, which include economic fundamentals as explanatory variables to exchange rate determination. One of these, the Behavioural Equilibrium Exchange Rate (BEER) model uses more advanced econometric estimation techniques to calculate equilibrium exchange rates.[4]

The BEER approach is founded on the notion that the real exchange rate is driven by a set of economic fundamentals. Consider the equation

[4] Other alternatives include the Fundamental Equilibrium Exchange Rate (FEER), proposed by Williamson (1994), and the Natural Real Exchange Rate (NATREX) from Stein (1994). In the FEER approach the equilibrium exchange rate is defined as the exchange rate that satisfies internal and external balance. As the external balance is dependent on assumptions about a sustainable current account balance the FEER is considered as a normative approach. NATREX starts from a situation of macroeconomic balance, but in contrast to the FEER, capital flows are determined by the difference between national saving and investment. The FEER is typically evaluated with the use of macroeconomic models, while the NATREX is commonly estimated by reduced-form equations.

$$q_t = \delta_0 + \delta_1 z_t + \varepsilon_t , \quad (1)$$

where z_t is a vector of economic fundamentals that affect the real exchange rate in the medium or long run. Any deviation from equilibrium is reflected in the ε_t term, which includes both short-term influences and random disturbances. The equilibrium real exchange rate ($\bar{q}_t$) is thus defined as

$$\bar{q}_t = \delta_0 + \delta_1 z_t . \quad (2)$$

The choice of economic fundamentals varies among studies. We refer here to the popular theoretical model advanced by Faruqee (1995) and extended by Alberola et al. (2001), Hansen and Roeger (2001) and Lorenzen and Thygesen (2002). In this model, the systematic component of the exchange rate is driven by the productivity differential between the home country and abroad (PROD), the net foreign asset position (NFA) and demand factors. Since demand factors are difficult to measure, they are commonly ignored in empirical studies. Thus, we get the following equation

$$\bar{q}_t = f(PROD_t, NFA_t) . \quad (3)$$

The impact of differences in the productivity growth on the real exchange rate is commonly known as the Balassa-Samuelson effect. It states that one country's relatively higher productivity increases are associated with a real appreciation of its currency. Several empirical studies find evidence of the Balassa-Samuelson effect in CEEC transition processes. An ECE (2001) study, for example, calculates a persisting effect of around 3 % annually. Fischer (2002) determines that about half of real exchange rate appreciation in accession countries can be can be attributed to the Balassa-Samuelson effect. He notes further that this effect seems to work not only through a supply channel but also through an investment demand channel.

The net foreign asset position affects the real exchange rate through several channels. A worsening of the net foreign position, for instance, means higher interest payments for net debtor countries on their debt and smaller incomes from interest payments for creditor countries. This has to be financed by an improvement in the trade balance, which requires a depreciation of the currency. Higher debt also leads to a rise in the risk premium. At some point, however, a higher yield can only be guaranteed if the domestic currency depreciates.

The econometric methodology for the application of the BEER approach in this paper is the cointegration technique as suggested by Johansen (1995). The starting point is a vector-error correction model (VECM)

$$\Delta x_t = \eta + \sum_{i=1}^{p-1} \Phi_i \Delta x_{t-i} + \Pi x_{t-1} + \varepsilon_t , \quad (4)$$

Where the (3x1) vector x_t = [RER_t, $PROD_t$, NFA_t]'. In the equation, η is a (3x1) vector of constants, ε represents a (3x1) vector of white-noise residuals, Φ denotes a (3x(p-1) matrix of short-run coefficients and Π is a (3x3) coefficient matrix. If Π has reduced rank r < 3, then there exist two (3xr) matrices α and β, such that $\Pi = \alpha\beta'$, where α is interpreted as the adjustment matrix and the columns of β are the linearly independent cointegrating vectors of the VECM. These cointegrating vectors determine the BEER.

2.2 Permanent equilibrium exchange rates

Another way to measure equilibrium exchange rates is to decompose times series into permanent and transitory components. The transitory component is characterized as having limited memory, while the permanent component is expected to have a persistent impact. The permanent component is then interpreted as a measure of equilibrium and forms the Permanent Equilibrium Exchange Rate (PEER). Several authors suggest procedures for decomposing time series [e.g. Cumby and Huizinga (1990), Clarida and Gali (1994)]. Here, however, we use a procedure from Gonzalo and Granger (1995), which explicitly considers the cointegration relationships among the variables and which provides a direct link to the BEER approach.

The PEER concept has typically been applied to western industrialized countries. Clark and MacDonald (2000) focus on the exchange rates of the United States, Canada and the United Kingdom. Alberola et al. (1999) use a sample of various industrialized economies, including several western European countries. Maesco-Fernandez et al. (2001) focus on the euro-dollar exchange rate.

The permanent component of a series is typically associated with a non-stationary, i.e. an I(1), process, while the transitory component is stationary or I(0). Gonzalo and Granger (1995) demonstrate that the results from the VECM can be used to identify both components. If the time series are cointegrated, the matrix Π has a reduced rank r < n and there are n – r common factors (f_t). With the assumptions that the common factors are linear combinations of the variables and that the temporary component does not Granger-cause the permanent component, the common factors may be given as

$$f_t = \alpha_\perp x_t \, . \tag{5}$$

This identification of the common factors makes it possible to decompose the time series x_t = [RER$_t$, PROD$_t$, NFA$_t$]' into permanent $x_t^P = \left[\mathrm{RER}_t^{\mathrm{perm}}, \mathrm{Prod}_t^{\mathrm{perm}}, \mathrm{NFA}_t^{\mathrm{perm}}\right]'$ and transitory $x_t^T = \left[\mathrm{RER}_t^{\mathrm{trans}}, \mathrm{Prod}_t^{\mathrm{trans}}, \mathrm{NFA}_t^{\mathrm{trans}}\right]'$ components

$$\bar{x}_t^P = A_1 \alpha'_\perp x_t = \beta_\perp (\alpha'_\perp \beta_\perp)^{-1} \alpha'_\perp x_t \, , \tag{6}$$

and

$$\bar{x}_t^T = A_2 \beta' x_t = \alpha (\beta' \alpha)^{-1} \beta' x_t \, . \tag{7}$$

The orthogonal components offer further insight into the system. The $\alpha_\perp$ vectors span the space of the common stochastic trends and thus identify the underlying driving forces, while $\beta_\perp$ gives the loadings associated with $\alpha_\perp$, i.e. those variables driven by common trends. Another source of information is the moving average representation of the VECM as proposed by Johansen (1995)

$$x_t = C \sum_{i=1}^{t} \varepsilon_i + C\eta + C(L)(\varepsilon_t + \eta) \, , \tag{8}$$

where

$$C = \beta_\perp (\alpha'_\perp (I - \sum_{i=1}^{k-1} \Phi_i) \beta_\perp)^{-1} \alpha'_\perp \, .$$

The C-matrix measures the combined effects of the orthogonal components, i.e. the long-run effects of shocks to the system.

3 Data overview

The following CEECs are included in our empirical analysis: Poland, Hungary, the Czech Republic, Slovenia and Estonia. For the calculation of effective rates, we add to the sample Lithuania, Latvia, Bulgaria, Romania, Slovakia, the twelve initial participants in the euro, the United States, the United Kingdom, Japan and Russia.
Quarterly data are used for all time series. Most were obtained from the International Financial Statistics (IFS) database. Gaps in the time series are filled with data from national statistics. The sample for the CEECs starts, depending on the introduction of the current convertible currency, between 1990 Q1 and 1993 Q1 and ends in 2002 Q1 for all countries. The time series for the industrialized countries go back as far as 1981 Q1.[5] The variables are used in the empirical analysis encompass real effective exchange rates, productivity levels and the net foreign asset position.

3.1 Real effective exchange rates

The real exchange rate is defined here as the log of a CPI-deflated index. For the computation of effective exchange rates, we use trade weights based on cumulated export and import volumes from the 1996 International Trade Statistics Yearbook for all 15 countries in the study.[6] The log real effective exchange rate for country i (q_i) is thus the trade-weighted average of the log bilateral real exchange (e_{ij}) rates vis-á-vis its trading partners

$$q_i = \sum_j w_{ij} \, e_{ij} \,, \qquad (9)$$

where the trade weights w_{ij} add up to one $\sum_j w_{ij} = 1$.

It is necessary to construct an artificial value for the euro preceding its introduction, i.e. up to 1998 Q4. This value is based on the real exchange rates of the twelve participating countries with each country weighted by the share of trade with economies outside the European Union.

3.1.1 Productivity levels

A direct measure for CEEC productivity levels on a quarterly basis does not exist. Thus, following standard practice, we take relative sectoral prices as a proxy.[7] Indeed, the studies by de Gregory et al. (1994) and Canzoneri et al. (1999) testify to a close link between sectoral productivity and sectoral prices. In practice, we take the log of the ratio of the domestic consumer price index to the domestic producer price index relative to the corresponding foreign ratio using the same trade weights as above, i.e.

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[5] The time series for Poland and Hungary start in 1990, Slovenia in 1992, and Estonia and the Czech Republic in 1993. A more detailed description is available from the authors upon request.
[6] The trade matrix includes 14 countries, as well as the aggregated euro region. Again, details are available upon request.
[7] Examples for the application of this proxy are given in Alberola et al. (1999), Chinn (1999), and Clark and MacDonald (1999).

$$\Pr od_{i,t} = \log\left(\frac{CPI_{i,t} / WPI_{i,t}}{\prod_{\forall j \neq i} (CPI_{j,t} / WPI_{j,t})^{w_j}} \right).$$

For the euro we again use the weights of the trade share with economies outside the European Union to calculate the numerator in the equation above.

3.1.2 Net foreign asset position

Data availability restricts the direct use of figures on net foreign assets. Fortunately, for nearly all countries we have numbers for the first quarter of 1998.[8] From that point, it is a straightforward task to add up current account balances to compute net foreign asset positions for previous and past periods.[9] Net foreign assets are normalised by nominal GDP to adjust for the size of each country.

4 Estimated equilibrium exchange rates

4.1 BEER results

The application of the BEER approach in a cointegration framework requires that at least some variables are non-stationary. Therefore, we perform unit-root tests to evaluate the order of integration. Table 1 presents the results for the well-known augmented Dickey-Fuller (ADF) test. The outcome shows that, except for the case of the real exchange rate and the productivity differential in Poland, we cannot reject the null hypotheses of a unit root.

Table 1. Time series dimensions and ADF unit-root tests

	Time series	RER	PROD	NFA
Poland	1990:1 to 2002:1	-4.53 (0) **	-5.28 (0) **	-0.26 (1)
Hungary	1990:1 to 2002:1	-2.49 (0)	-0.98 (0)	-1.07 (1)
Czech Republic	1993:1 to 2002:1	-1.83 (0)	-2.42 (1)	-2.60 (2)
Slovenia	1992:1 to 2002:1	-2.59 (0)	-1.32 (2)	-1.24 (1)
Estonia	1993:1 to 2002:1	-2.23 (0)	-2.75 (4)	0.68 (1)

5 % Critical Value: -2.96; 1 % Critical Value: -3.66. Number of lags for Dickey-Fuller Test in parenthesis.

In addition to the ADF test, we employ a unit root test suggested by Perron (1997). This test allows for an endogenously determined structural change in the time series.[10]

[8] In the cases of Greece and Portugal, current account data were added up historically as no figures on net foreign asset positions were available.

[9] The time series were seasonally adjusted using the additive X-12 method when tests suggested seasonality.

[10] Perron (1997) actually gives a variety of options for structural breaks. In this paper, we allow for a structural break in the intercept and in the slope of the time series. The breakpoint is determined endogenously.

Transition economies are likely candidates for structural breaks in time series, since most of them experienced significant changes in policymaking in the course of transition. For example, a switch of the exchange rate regime may cause such a structural break.[11] Table 2 shows the results for the unit root test statistic and the respective break date. The outcome is mixed. Concerning the real exchange rate in three CEECs, the null hypothesis of a unit root can be rejected at the 5 % level. On the other hand, in the majority of countries the null hypothesis cannot be rejected in the case of the productivity differential and the net foreign asset position. Looking at the break date, the structural shift for the real exchange rate is most evident in the third quarter of 1998. This coincides with the beginning of the Russian exchange rate crisis, which severely affected the CEECs. This event must therefore be considered in the cointegration system.

Table 2. Perron (1997) unit root tests with structural breakpoints

	RER		PROD		NFA	
	Test statistic	Break date	Test Statistic	Break date	Test statistic	Break date
Poland	-5.48 (2)	1998:3	-6.33 (0)**	1998:1	-6.29 (0)*	1994:2
Hungary	-4.76 (4)	1992:2	-3.62 (1)	1995:4	-3.81 (0)	1999:3
Czech Republic	-5.85 (0)*	1998:3	-6.37 (4)**	1998:1	-4.61 (1)	1995:4
Slovenia	-5.82 (3)*	1998:3	-5.05 (5)	1998:1	-2.86 (4)	1993:4
Estonia	-5.80 (5)*	1998:3	-4.81 (3)	1994:4	-3.98 (0)	1994:2

5 % Critical Value: -5.50; 1 % Critical Value: -6.32. Number of lags in parenthesis.

We next conduct the panel unit root test proposed by Im, Pesaran and Shin (1995) to control for the results of the univariate tests. Panel estimation techniques continue to gain popularity, because the power of tests can be augmented with the addition of cross-sectional dimensions. Given the short time series of the sample, these techniques provide an opportunity to check for the robustness and adequacy of our model. For the panel estimation, we thus examine the period from 1993 Q1 to 2002 Q1, when observations for all countries are available. This test is based on the average of each individual ADF unit root test and hence allows for heterogeneity in the panel. We find the test statistic under the null hypothesis of a unit root is distributed as a standard normal. Table 3 indicates that the null hypothesis is not rejected in any of the three variables.

Table 3. IPS panel unit root test

	Test result	Critical value
Exchange rate	-1.50	-1.69
Productivity	-1.51	-1.69
Net foreign assets	-1.22	-1.69

The next step is to perform cointegration tests for each country. Table 4 presents the results of the cointegration tests for our five accession countries. The test statistics here are adjusted using the small sample correction suggested by Reimers (1992). The numbers indicate single cointegration relationships in all five cases. These results have to be taken

[11] Kocenda (2001) found structural breaks in real and nominal exchange rates in several, though not all, transition economies. These structural breaks do not necessarily coincide with changes in exchange rate policy.

with caution, because they include an exogenous Russian crisis dummy.[12] The Russian exchange rate crisis in 1998 had a strong adverse impact on the determined real exchange rates and productivity effects as on the one side the slump of the Russian rouble appreciated the real exchange rate of their trading partners and on the other side depreciated their calculated relative price index due to the high imported inflation in Russia. Once the situation in Russia stabilized, this effect reversed. Because of the short time series, this period induces a negative relationship between these two variables and requires that we adjust the model. We use a dummy that captures the average effect on the most affected countries.[13] Although not all economies in the sample responded strongly to Russia's financial crisis, we use dummy in all country studies for the purpose of consistency.

Table 4. Cointegration tests

	Null hypothesis	Eigenvalue	Trace statistic			Max-Eigen statistic		
			Statistic	5 % Critical value	1 % Critical Value	Statistic	5 % Critical Value	1 % Critical Value
Poland	at most 1	0.45	**50.70	29.68	35.65	**39.09	20.97	25.52
	at most 2	0.12	11.61	15.41	20.04	8.64	14.07	18.63
	at most 3	0.06	2.96	3.76	6.65	2.96	3.76	6.65
Hungary	at most 1	0.44	*35.53	29.68	35.65	*25.33	20.97	25.52
	at most 2	0.17	10.20	15.41	20.04	8.33	14.07	18.63
	at most 3	0.04	1.87	3.76	6.65	1.87	3.76	6.65
Czech Republic	at most 1	0.60	*32.64	29.68	35.65	*24.43	20.97	25.52
	at most 2	0.17	8.21	15.41	20.04	5.14	14.07	18.63
	at most 3	0.11	3.07	3.76	6.65	3.07	3.76	6.65
Slovenia	at most 1	0.64	**50.49	29.68	35.65	**36.22	20.97	25.52
	at most 2	0.32	14.27	15.41	20.04	13.74	14.07	18.63
	at most 3	0.01	0.53	3.76	6.65	0.53	3.76	6.65
Estonia	at most 1	0.57	**36.78	29.68	35.65	*24.91	20.97	25.52
	at most 2	0.29	11.87	15.41	20.04	10.00	14.07	18.63
	at most 3	0.06	1.87	3.76	6.65	1.87	3.76	6.65

* means rejection at the 5 % critical value; ** means rejection at the 1 % critical value.

Like the time series, the cointegration relationship can also be exposed to structural change. Thus, we apply the SupF test proposed by Hansen (1992) to test for parameter instability in the cointegration relationship with an a priori unknown breakpoint. The SupF test is particularly appropriate for testing for swift shifts such as a change in the exchange rate regime.[14] Figure 1 in the appendix presents the results.[15] The null hypothesis of constant coefficients cannot be rejected for Poland, Hungary, Slovenia and the Czech Republic, since the critical value exceeds the test statistics in all time periods. The

[12] The inclusion of exogenous variables leads to slightly different critical values than the ones presented in this table.

[13] Only the most affected countries were taken since here the impact could be isolated more clearly from other influences.

[14] The SupF test is based on the fully modified estimator from Phillips and Hansen (1990).

[15] This test requires the exclusion of the endpoints of the time series. Therefore, we cut off about 15% of the observations in the beginning and the end of the time period as suggested by Andrews (1990).

exception is Estonia, which displays structural breakpoints near the end of the observed time period.[16] Overall, there is a relatively high stability in the cointegration relationship.
As in the case of the unit root tests we also use panel estimation techniques to check the results. Pedroni (1999) suggests seven different test statistics for testing the null hypothesis that for each member of the panel the variables are not cointegrated against the alternative that for each member of the panel the variables are cointegrated. The test statistic is standard normally distributed. Table 5 shows the null hypothesis is rejected in five out of the seven cases in our sample. Although we do not get a definitive answer, we conclude there is a cointegration relationship.

Table 5. Panel cointegration tests

	Test result	Critical value
Panel V-statistic	3.07	1.69
Panel Rho-statistic	-1.24	-1.69
Panel PP-statistic	-1.75	-1.69
Panel ADF-statistic	-2.12	-1.69
Group Rho-statistic	-1.31	-1.69
Group PP-statistic	-1.87	-1.69
Group ADF-statistic	-3.07	-1.69

Moving to the estimation of the cointegration relationship, Table 6 presents the normalised cointegrating vectors, as well as the corresponding adjustment coefficients from the Johansen (1995) methodology. As theory suggests, the productivity differential and net foreign asset position have a positive and significant impact on the real exchange in all countries. The absolute value of the coefficient for the Balassa-Samuelson effect is far higher than that of the net foreign asset position in all countries. This does not, however, mean that the influence of the net foreign asset position is necessarily less intense; the volatilities of the variables also have to be considered. Taking the time series standard deviations of the two fundamentals and multiplying them with the coefficients reveals that in Poland and Estonia the productivity effect clearly dominates, while in Slovenia the net foreign asset position plays a major role. In the Czech Republic and Hungary, the impacts of both fundamentals are similar. Studies on OECD countries [e.g. Alberola et al. (1999) and Clark and MacDonald (2000)] find productivity coefficients between 0.60 and 2.00 and net foreign asset coefficients between 0.01 and 1.00. Thus, the magnitude of the calculated numbers here is well in line with those results. The significantly negative alpha coefficient in all countries indicates that the real exchange rate adjusts to close any deviation from the equilibrium. However, the speed of adjustment varies among transition economies. While the adjustment speed for Hungary, Slovenia and Estonia is as expected, the Czech Republic and Poland show very rapid adjustment (with an overshooting in the case of Poland). This could reflect the stationary behaviour of the time series suggested by the ADF unit root test. The insignificant alpha coefficient for the net foreign asset position suggests weak exogeneity. The results for the productivity differential are mixed, indicating interrelation among variables.

[16] The reasons for this outcome can be manifold. Possible explanations are the Russian crisis, a strong worsening of the net foreign asset position in recent periods, or the depreciation of the euro vis-á-vis most major currencies since Estonia is connected to the euro through a currency board.

Table 6. BEER estimation results

		Real exchange rate	Productivity differential	Net foreign asset position
Poland	Coefficient	1	-1.29	-0.05
	(t-value)		(-19.93)	(-2.14)
	Alpha	-1.33	-0.25	0.26
	(t-value)	(-3.52)	(-1.83)	(0.48)
Hungary	Coefficient	1	-1.84	-0.18
	(t-value)		(-7.15)	(-4.74)
	Alpha	-0.32	0.11	-0.33
	(t-value)	(-2.55)	(2.76)	(-1.85)
Czech Republic	Coefficient	1	-1.03	-0.04
	(t-value)		(-2.53)	(-2.08)
	Alpha	-0.77	-0.02	-0.23
	(t-value)	(-3.53)	(-1.70)	(-1.89)
Slovenia	Coefficient	1	-0.79	-0.53
	(t-value)		(-1.97)	(-5.62)
	Alpha	-0.53	-0.18	0.4
	(t-value)	(-2.17)	(-2.31)	(1.75)
Estonia	Coefficient	1	-2.19	-0.08
	(t-value)		(-14.84)	(-3.79)
	Alpha	-0.34	0.14	0.07
	(t-value)	(-6.25)	(1.62)	(0.52)

We also apply panel estimation techniques and employ the fully modified ordinary least squares (FMOLS) estimator from Pedroni (2000) to compute coefficient estimates for cointegrating vectors. This estimator takes account of the spurious regression problem that typically arises when pooled OLS or fixed effects models are used on non-stationary data. The estimator from Pedroni (2000) allows for heterogeneity in short-run responses and intercepts, while long run relationships are common for the panel.

We present the cointegration vector for the panel in Table 7. Again, both the productivity differential and the net foreign asset position have a positive and significant impact on the real exchange rate. The magnitude of the parameters is comparable with the estimated coefficients in the BEER analysis, although on average slightly smaller. The t-statistics in parenthesis indicate strong significance and, hence, confirm the adequacy of the chosen model. Though the FMOLS estimator also delivers country-specific estimates, the results were in most cases of little use for computing equilibrium exchange rates. One reason for this may be that countries in transition respond so heterogeneously to changes in fundamentals that single-country estimates from above should be preferred.

Table 7. Panel FMOLS estimation results

	Real exchange rate	Productivity differential	Net foreign asset position
Panel coefficients	1	-0.81	-0.06
(t-value)		(-7.15)	(-12.34)

Taking the single-country estimates, we compute the BEERs and compare them with the real exchange rates. Figure 2 in the appendix gives the real exchange rate, the BEER and the deviations from equilibrium for each country. Looking first at the real exchange rates, we see appreciating currencies in all countries during the transition process (although the magnitude of appreciation varies significantly among individual economies). Poland and Estonia have experienced a comparatively strong and steady appreciation. Although the Polish currency was highly undervalued in the early nineties, the zloty has been consistently overvalued since 1998. Estonia experienced a critical overvaluation during the Russian exchange rate crisis. While this overvaluation has been reduced in recent years, it has yet to be eliminated completely. Heavy speculation against the Czech koruna in May 1997 led to a sharp depreciation. When speculation on the exchange rate market abated, the Czech koruna surged to a level of overvaluation higher than prior to the crisis, provoking a second major correction. The koruna's real exchange rate is again on an upswing, and currently the Czech currency is overvalued almost 10 %. The appreciation of the Slovenian koruna and Hungarian forint has been of much more modest. Currently, the Slovenian koruna is slightly overvalued and the Hungarian currency is perhaps slightly undervalued. In Hungary's case, the temporary peak in mid-1998 coincides with Russia's financial crisis.

The BEER approach has been applied to transition countries in several studies.[17] Filipozzi (2000) examines the case of Estonia for the period between 1993 Q2 and 1999 Q2. He finds that the initial undervaluation of around 25-30 % turned to an overvaluation of about 5 % after the Russian crisis. Kemme and Tang (2000) also use a single equation error-correction model to investigate the case of Poland. The results show an undervaluation of the real exchange rate until 1996, followed by a moderate overvaluation until the end of the sample period in mid-1999. Égert (2002) combines the BEER approach with elements of the FEER approach by applying a three-equation cointegration model. Five CEECs are included in the sample and the real effective exchange rate is based on the German mark and the US dollar (the weights correspond to the trade shares for the European Union and the rest of the world, respectively). Égert's results indicate that the real exchange rates in Hungary and Slovenia are not overvalued, but there are signs of a substantial overvaluation for the currencies of Poland, Slovakia and the Czech Republic.

Kim and Korhonen (2002) employ a pooled mean group and the FMOLS estimator from above on a sample of 29 middle and high-income countries. The resulting cointegration equation linking the real exchange rate to a set of four fundamentals was applied to a sample of central European transition economies to generate equilibrium real exchange rates for these countries. The results show an overvaluation in 1999 (the time for which the real effective exchange rates are calculated) of 8 % for Poland and Slovakia, 12 % for the Czech Republic and up to 40 % for Hungary.

4.2 Calculation of bilateral exchange rates

So far, we have calculated multilateral real equilibrium exchange rates. These rates, however, tell us nothing about the relation of these eastern European currencies against the euro. Nevertheless, the reference rate at entry into the ERM2 system will be chosen in relation to the euro and not against a basket of currencies. For our purposes and for

[17] Smidkova (1998), in contrast to the other studies, employed a FEER approach on the Czech Republic. She estimates a band of overvaluation between –1.4 % and 6.8 % in 1996.

policymakers, it is much more informative to evaluate bilateral exchange rates. Fortunately, calculating bilateral exchange rates is only a small step, once we have determined the multilateral rates.[18] In fact, we can use cross rates to express any exchange rate e_{ij} in terms of an arbitrary numeraire currency (n). Thus,

$$e_{ij},= e_{jn} - e_{in} \ . \qquad (10)$$

Substituting (10) in the definition of the real effective exchange rate, equation (9), and doing so for all countries i = 1, …, n yields

$$q = (W - I)\, e, \qquad (11)$$

with $q = (q_1, q_2,...,q_n)'$ and $e = (e_1, e_2,...,e_n)'$. W is the (n x n) trade matrix and I is the identity matrix of order n.

One exchange rate in (11) is redundant, and can therefore be discarded without losing information. We then define $\overline{q} = (q_1, q_2, ..., q_{n-1})'$ as the [(n-1) x 1] vector where the numeraire real multilateral exchange rate has been discarded and $\overline{q}_{num} = (q_n, q_n, ..., q_n)'$ as the [(n-1) x 1] vector, which consists of the real multilateral exchange rate of the numeraire. Expressing the multilateral exchange rates relative to the numeraire currency gives

$$\overline{q} - \overline{q}_{num} = (\overline{W} - \overline{I})\, \overline{e} - \overline{q}_{num}\,, \qquad (12)$$

where a line on top of matrices means that the n[th] row and column have been deleted and where $\overline{e} = (e_1, e_2, ..., e_{n-1})'$ is the [(n-1) x 1] vector. Using (9) to rewrite this equation, we obtain

$$\overline{q} - \overline{q}_{num} = [(\overline{W} - \overline{I}) - \overline{W}_{num}]\, \overline{e}\,, \qquad (13)$$

where $\overline{W}_{num}$ consists of the vectors $q = (q_{n1}, q_{n2},...,q_{nn-1})'$ as the rows of the matrix. Pre-multiplying both sides by the inverse of the [(n-1) x (n-1)] matrix $Z \equiv [(\overline{W} - \overline{I}) - \overline{W}_{num}]$ yields the derivation of bilateral equilibrium exchange rates

$$\overline{e} = Z^{-1}\, (\overline{q} - \overline{q}_{num})\,. \qquad (14)$$

This method only works if the exchange rate vector encompasses the whole world. Thus, the rest of the world (ROW) must be included in our analysis.[19] Though we do not have any information about the rest of the world, the most plausible assumption about the multilateral real exchange rate of the ROW it that it is constantly in equilibrium. This means that there are no deviations from the equilibrium real exchange rate. As the weights of the ROW in the trade matrix are relatively small, this assumption plays a minor role in the calculation of the bilateral rates. Applying this assumption, we rewrite equation (14) in terms of deviations from equilibrium

$$\hat{\overline{e}} = \hat{Z}^{-1}\, (\hat{\overline{q}} - \hat{\overline{q}}_{num})\,. \qquad (15)$$

The results from this algebraic transformation appear in Figure 3 in the appendix. Not

[18] The following calculations have been formalized by Alberola et al. (1999).
[19] In practical terms, the trade matrix has to be adjusted including the trade share of the ROW.

surprisingly, the periods of overvaluation and undervaluation quite well match the results from the multilateral case. Notably, the period since 1999 shows clear differences in the magnitude of deviations from equilibrium. In all countries, the overvaluation is higher. The Hungarian forint, for example, is now slightly overvalued. This observation reflects the weakness of the euro against all other major currencies during this time. Recently, the euro has appreciated strongly against the US dollar, UK pound and Japanese yen, while the nominal exchange rates of most Eastern European currencies have remained fairly stable. This applies particularly to Estonia, Hungary and the Czech Republic. The exchange rates of Poland and Slovenia depreciated slightly against the euro during this period.[20] Overall, this development increases the burden on CEECS as their real effective exchange rates have tended to appreciate.

4.3 PEER results

Figures 4 and 5 present the results of the multilateral real and the bilateral nominal PEER. The results are qualitatively broadly in line with the ones from the BEER analysis. There are some quantitative differences, however. In Poland, the undervaluation was higher in the beginning of the transition process, which over the entire period inverted to a comparatively higher overvaluation in the first quarter of 2002. Looking at Hungary, the peak overvaluation in 1998 from the BEER approach seems to have been caused mainly by transitory influences; the PEER approach shows a much smaller peak. The PEER analysis reveals that the Russian crisis had a rather persistent effect on the exchange rate in Estonia so that the kroon is still highly overvalued. The PEER also shows higher overvaluation in the first quarter of 2002 than the BEER (see Table 8). Considering both methods, we find critical overvaluations for Poland, Estonia and the Czech Republic. Hungary and Slovenia have little apparent cause for exchange rate adjustments.

Table 8. Exchange rate overvaluation (2002 Q1)

	BEER (multi-lateral)	BEER (bilateral euro)	PEER (multi-lateral)	PEER (bilateral euro)
Poland	+ 8.6 %	+ 12.7 %	+ 13.2 %	+ 16.9 %
Hungary	- 1.7 %	+ 2.5 %	+ 4.9 %	+ 8.6 %
Czech Rep.	+ 9.7 %	+ 13.7 %	+ 11.0 %	+ 14.7 %
Slovenia	+ 2.6 %	+ 6.0 %	+ 3.4 %	+ 6.5 %
Estonia	+ 5.3 %	+ 10.2 %	+ 7.4 %	+ 11.6 %

This PEER derivation also yields insight to the underlying forces of the system. Table 9 displays the orthogonal components $\alpha_{\perp}$ and $\beta_{\perp}$, as well as values of matrix C from equation (10). Closer inspection of matrix $\alpha_{\perp}$ shows that the variables associated with the highest value in each vector indicate which factor drives the common trends.[21] The results show that the productivity differential contributes most to the first common trend in all economies. Although the picture is more ambiguous for the second trend, net foreign asset

[20] Lately, the Hungarian Central Bank devalued the central parity against the euro by about two per cent as a reaction to the recent appreciation and in the view of a less favourable economic outlook for the near future.
[21] Since there are no tests for the significance available, these results should be interpreted with prudence.

position still has the strongest influence in every case. The highest values of the orthogonal component $\beta_\perp$ disclose, which common trend has the strongest impact on each factor. The numbers show that the exchange rate is mainly driven by the first common trend and only to a lesser extent by the second one. The influence of the trend related to the net foreign asset position is highest in the case of Slovenia.

The impact matrix C from equation (10) gives information about the reaction to shocks and can be used to check the consistency of the results. In all cases, the cumulative impact of a shock in the productivity differential and in the net foreign asset position is, as theory suggests, positive.

Table 9. PEER estimation results

		$\alpha_\perp^1$	$\alpha_\perp^2$	$\beta_\perp^1$	$\beta_\perp^2$	$\Sigma\, \varepsilon_{RER}$	$\Sigma\, \varepsilon_{PROD}$	$\Sigma\, \varepsilon_{NFA}$
Poland	RER	-0.2	0.14	0.79	0.03	-0.25	1.19	0.07
	PROD	0.98	0.01	0.61	-0.01	-0.24	1.03	-0.17
	NFA	0.01	0.99	-0.01	0.99	1.34	-2.9	5.22
Hungary	RER	0.25	-0.69	0.88	0.09	0.33	0.25	0.69
	PROD	0.96	0.1	0.48	-0.05	1.23	0.54	1.27
	NFA	0.1	0.71	-0.05	0.99	0.12	-0.04	1.12
Czech Republic	RER	-0.01	-0.29	0.72	0.03	-0.03	1.06	0.05
	PROD	0.99	-0.01	0.69	-0.01	-0.01	1.02	0.01
	NFA	-0.01	0.95	-0.01	0.99	-0.31	-2.9	1.01
Slovenia	RER	-0.26	0.58	0.57	0.39	0.12	0.34	0.73
	PROD	0.96	0.08	0.81	-0.12	0.59	0.46	0.42
	NFA	0.08	0.81	-0.13	0.91	0.42	-0.25	1.15
Estonia	RER	0.37	0.19	0.91	0.04	0.57	0.24	0.53
	PROD	0.93	-0.04	0.41	-0.02	1.21	0.53	0.56
	NFA	-0.04	0.98	-0.02	0.99	0.38	0.12	1.45

5 Conclusions

In this study, we applied two methods to calculate equilibrium exchange rates of five EU accession candidates. Our results from both the BEER and PEER approaches indicate overvaluations of the real exchange rate in all these countries. The size of the overvaluation, however, varies. Poland, Estonia and the Czech Republic are currently quite far from equilibrium, while Hungary and Slovenia are close to equilibrium. In all countries, overvaluation was accentuated when nominal bilateral equilibrium exchange rates against the euro were computed through algebraic transformation. The recent appreciation of the euro against major currencies such as the US dollar may exacerbate the overvaluation problem, because exchange rates of the CEECS against the euro have tended to be fairly stable.

The view on the computed numbers directly raises the issue of whether devaluation prior to joining ERM2 is a reasonable policy option. Obviously, such a measure must be considered carefully. In the first place, such a move implies that the exchange rate is amenable to control by the central bank or government. Moreover, even if the central bank fixes the nominal exchange rate at a particular value, it would only determine the real exchange rate over the short run, since monetary policy actions feed back on domestic inflation. More specifically, devaluation tends to raise prices by making imports more costly. Any adjustment of the real exchange rate will eventually be offset by the inflationary feedback. Finally, a deliberate weakening of the exchange rate, which improves competitiveness, is a two-edged sword. Other factors, such as productivity and the structure of production seem to be relevant factors for the determination of the economic position in world comparisons.

Nevertheless, substantial overvaluation, given the importance of external trade in these small open economies, could well slow economic growth. Indeed, on the eve of EU accession the bright economic prospects of these countries may well attract high capital inflows, creating further upward pressure on real exchange rates. However, any economic downturn during the participation in ERM2 might well change the expectations of international financial investors and lead to speculative attacks and financial crisis.

This paper suggests at least to areas for future research. First, no cointegration relationships were found for some CEECs, suggesting that other factors are at play in determination of real exchange rates. Second, increased power in estimation through the use panel estimation techniques still provides no concrete estimates of equilibrium exchange rates for the individual countries (although the overall impact of the Balassa-Samuelson effect and the net foreign asset position on the real exchange rate is substantiated). In any case, considerable work remains to be done on determination of equilibrium exchange rates and their application to transition economies.

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Appendix

Figure 1. SupF tests for parameter instability in the cointegration relationship

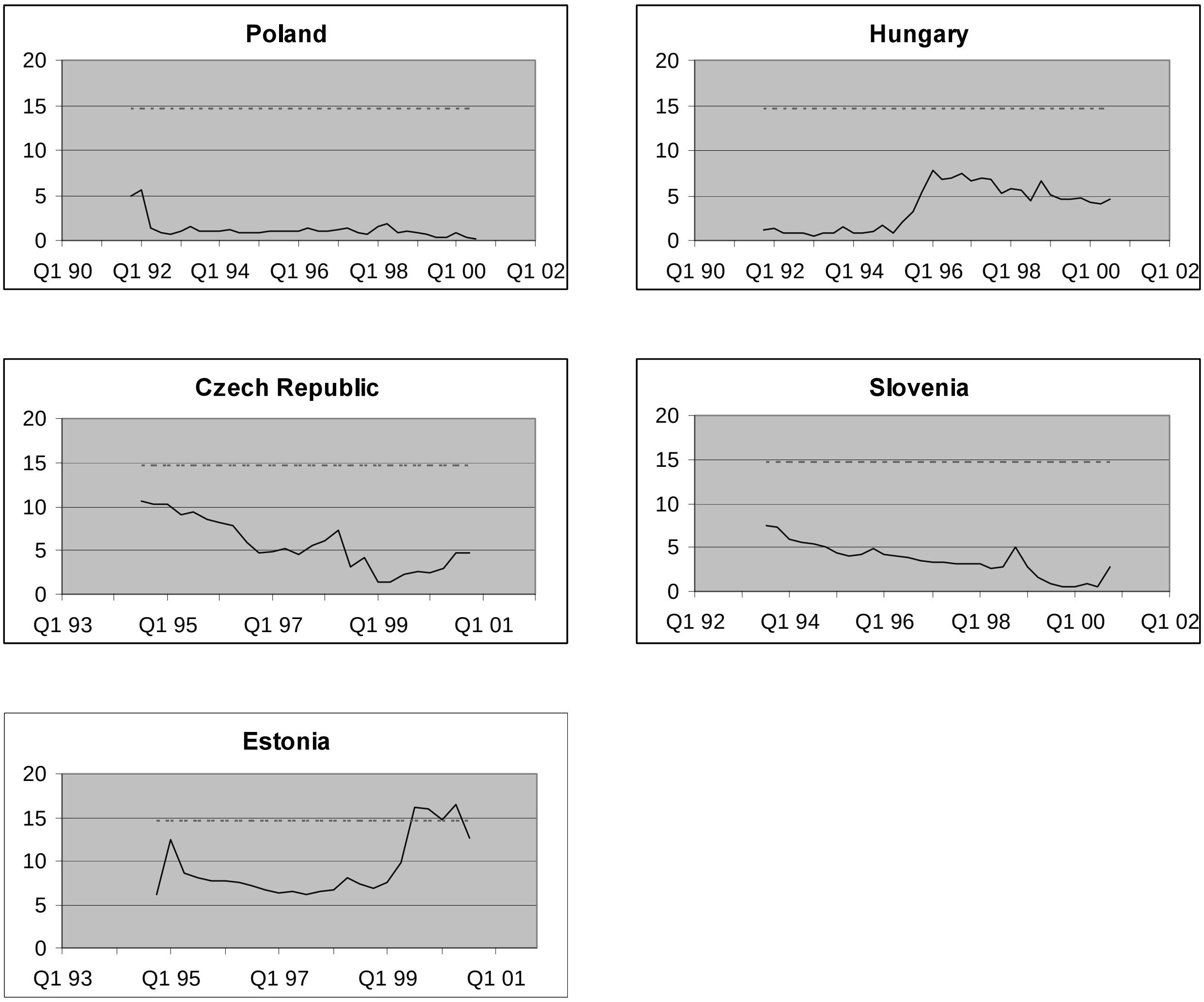


Figure 2. Real effective exchange rate (solid line), BEER (dashed line) and deviations from equilibrium (right panel)

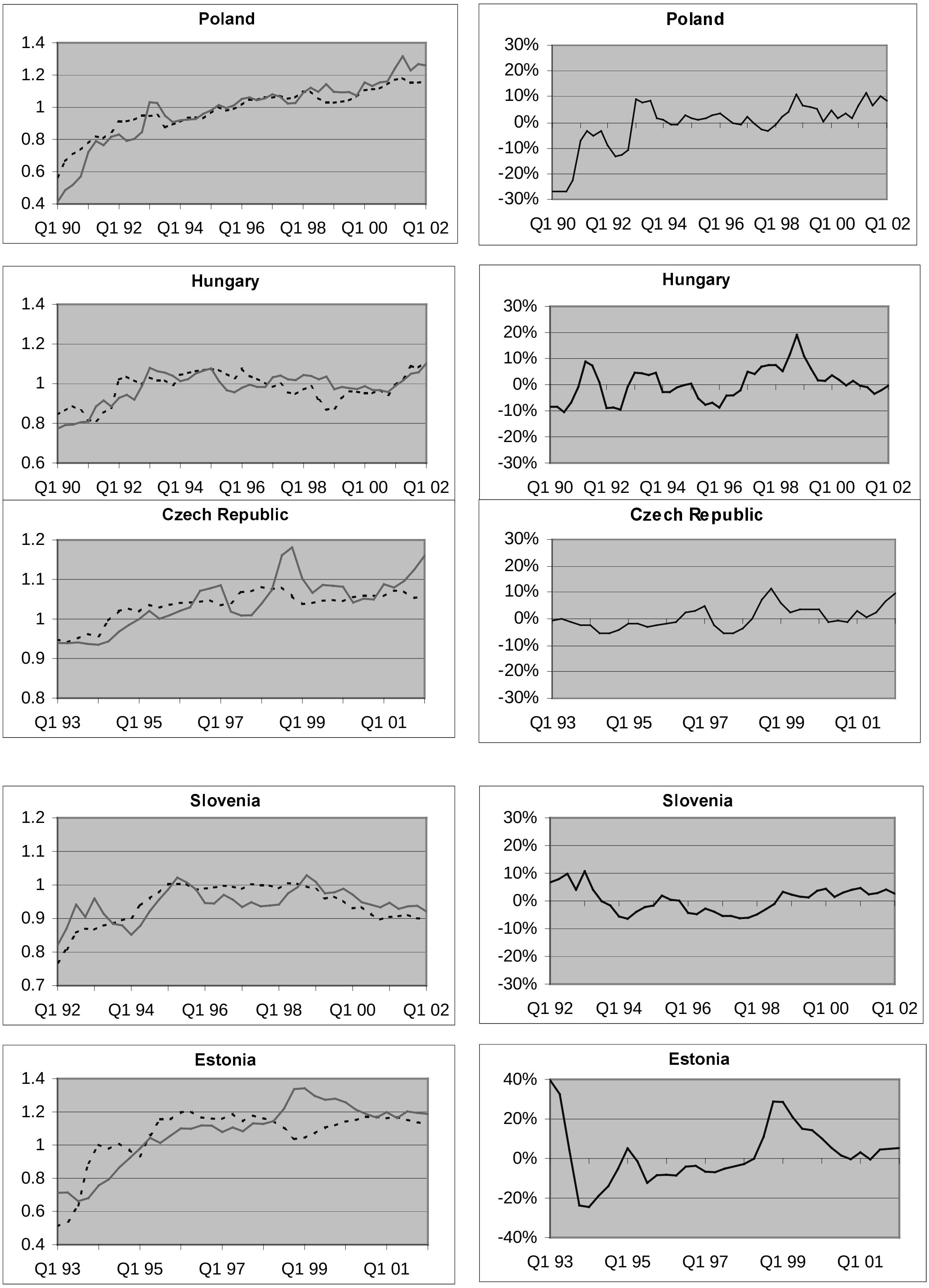


Figure 3. Nominal euro exchange rate (solid line), BEER (dashed line) and deviations from equilibrium (right panel)

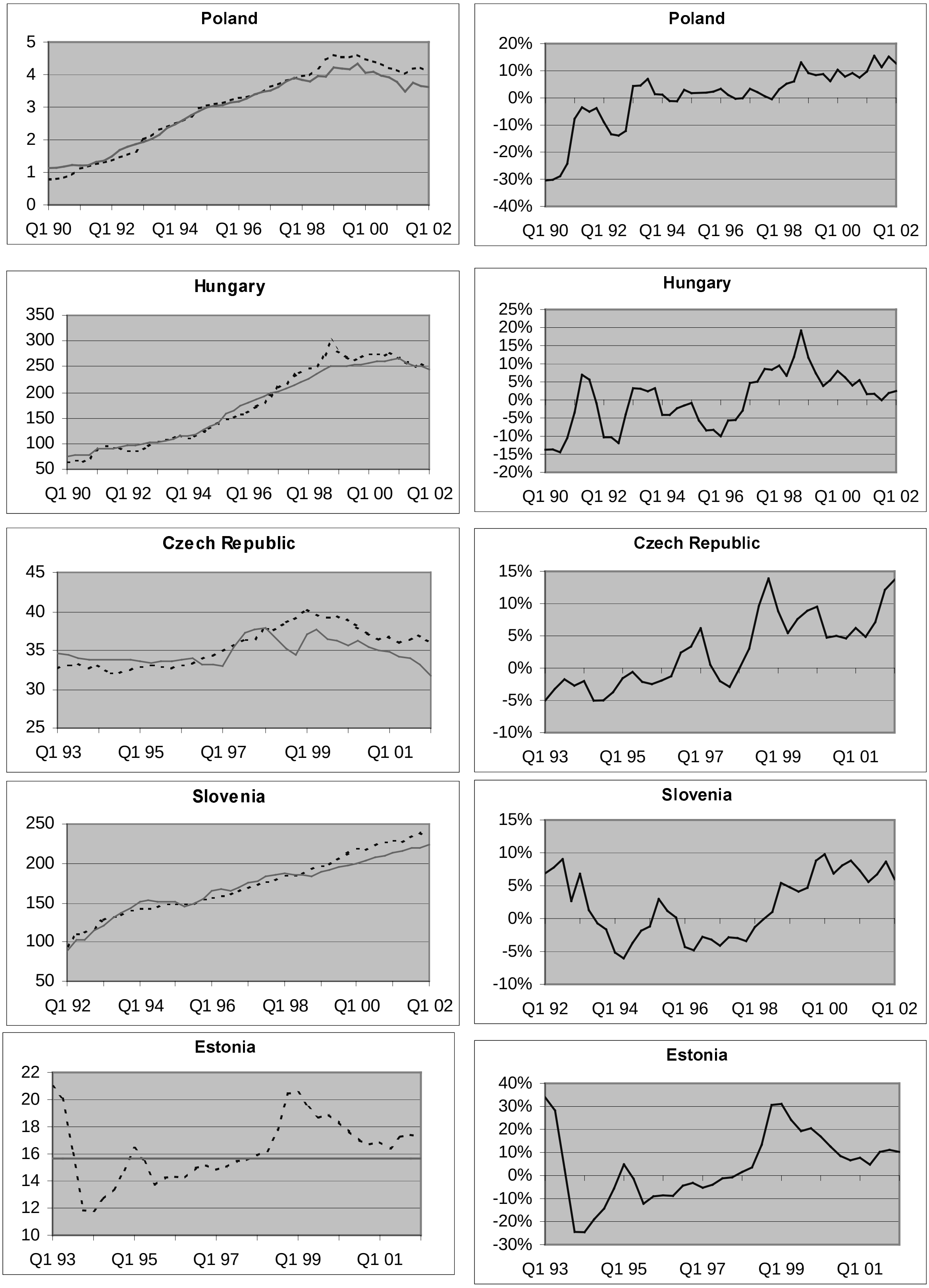


Figure 4: Real effective exchange rate (solid line), PEER (dashed line) and deviations from equilibrium (right panel)

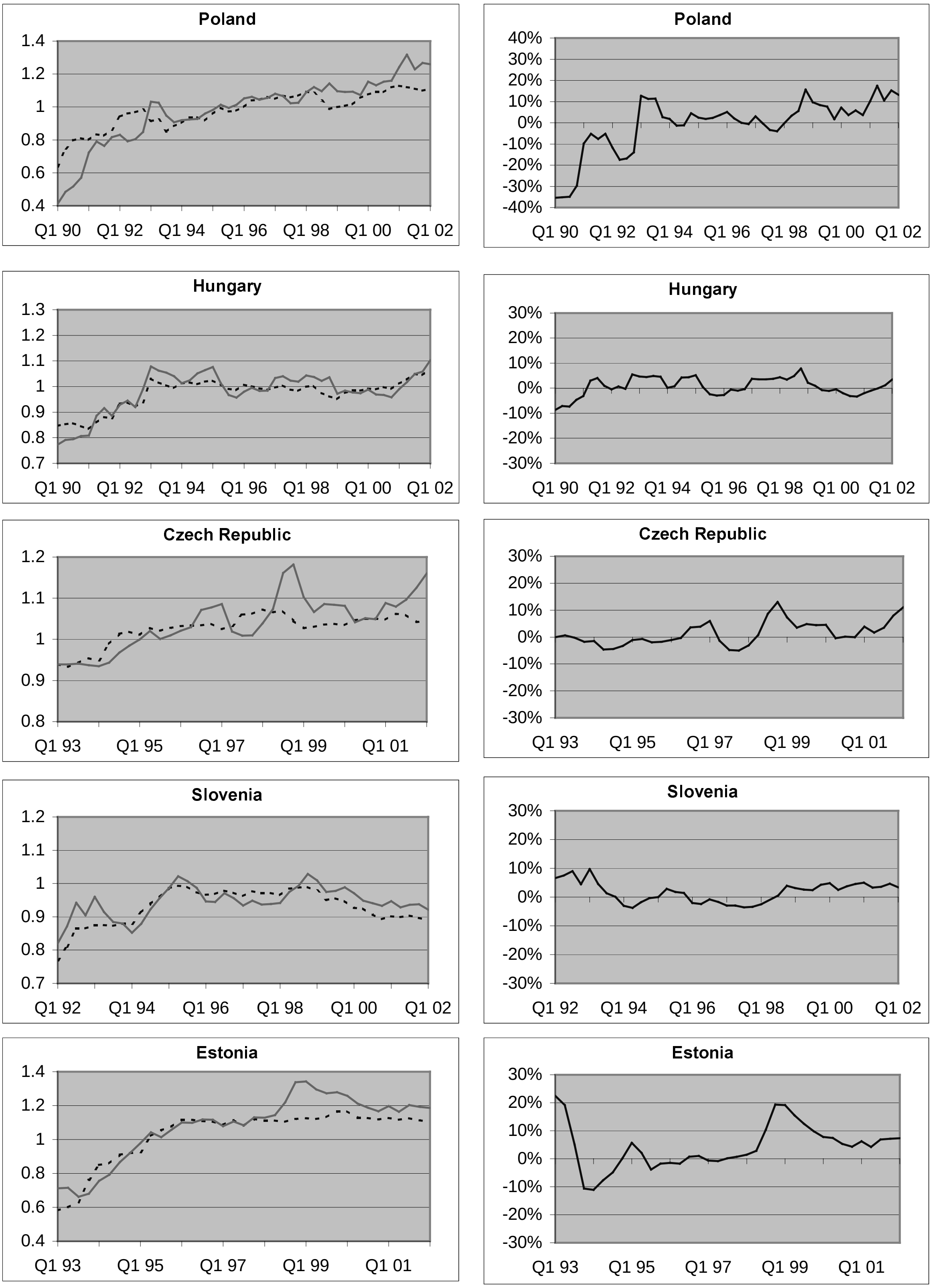
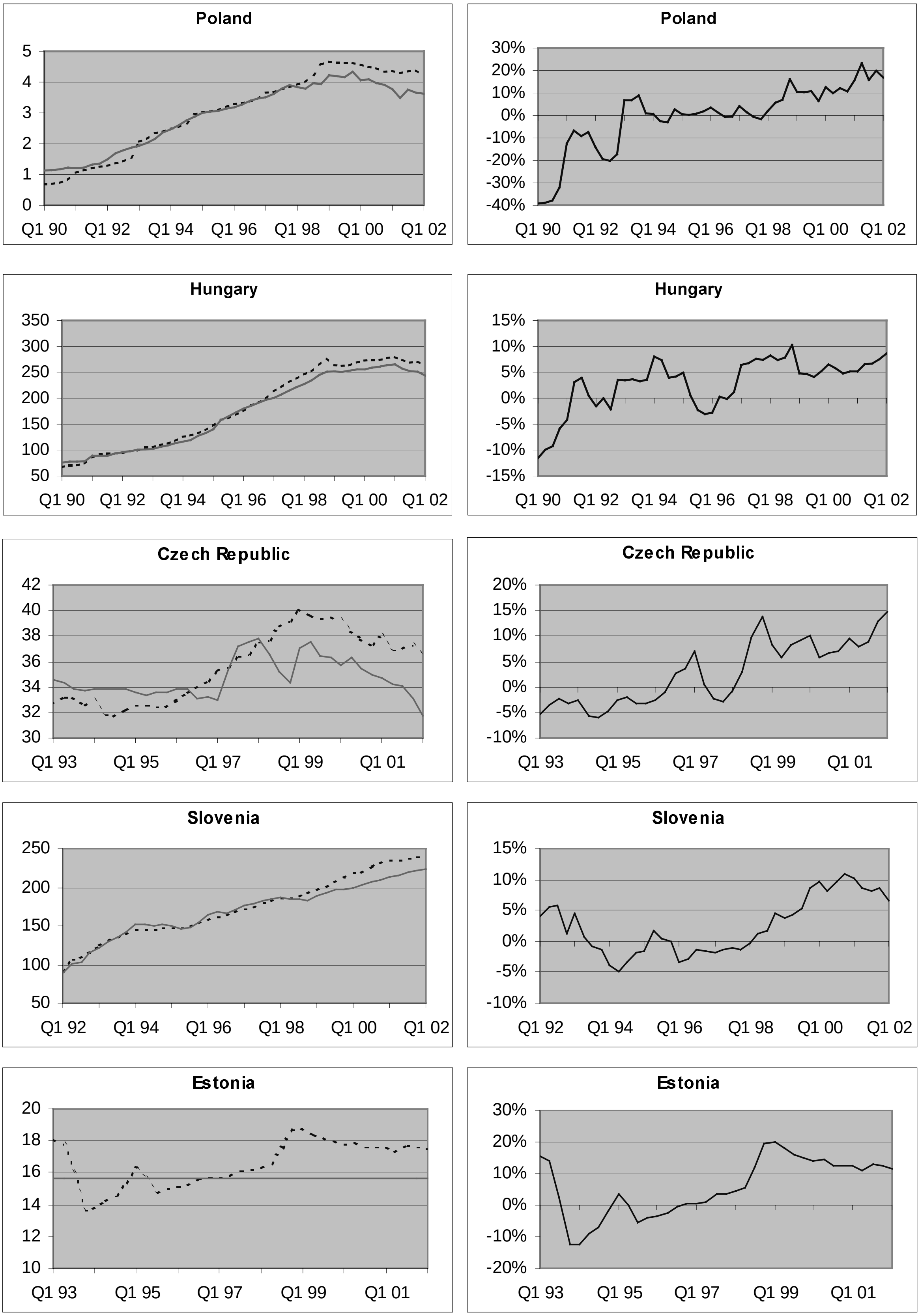


Figure 5: Nominal euro exchange rate (solid line), PEER (dashed line) and deviations from equilibrium (right panel)



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ISBN 951-686-870-3 (print)
ISSN 1456-4564 (print)

ISBN 951-686-871-1(online)
ISSN 1456-5889 (online)

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