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**Estimating Equilibrium Exchange Rates for the New
Member Countries of the European Union**

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Abstract: This paper estimates real equilibrium exchange rates for the new members of the European Union. First, an out-of-sample method is applied using a cointegrated panel of 25 OECD countries to estimate common coefficients for the panel. Next, individual constants for each of the new member countries are derived by a new methodology. Then these constants and the panel coefficients are combined to calculate the real equilibrium exchange rate for nine of the ten new members. Of these nine, only Slovenia's and the Czech Republic's rates are at or near their real equilibrium exchange rate.

Keywords: Equilibrium Exchange Rates, EU New Member Countries, Cointegration, Panel Estimation

JEL: C23, F31

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1 Introduction

Identifying equilibrium exchange rates is crucial for the transition of new European Union (EU) member countries (NMCs) into the Euro Area. In May 2004, ten central and eastern European countries¹ joined the EU and plan to adopt the euro in the next years; Slovenia is going to join the Euro Area already in 2007. To do so, a country must fulfill several criteria established by the Maastricht Treaty, including participation in the European exchange rate mechanism (ERM II) for no less than two years to maintain the convergence process to the euro area.² This paper focuses on this criterion. While being in the ERM II the countries' exchange rates with the euro are allowed to fluctuate around a central rate in a bandwidth of $\pm 15\%$. The national central banks and the European Central Bank can defend these margins. Modification of the central rate is possible, but adoption of the euro requires the central rate to remain unchanged for at least two years. Therefore, setting the central rate close to or at the equilibrium exchange rate is crucial to the success of a Euro Area entry.

Various approaches for estimating the equilibrium exchange rate for the NMCs are proposed in the literature with a variety of results. Studies can broadly be grouped country-by-country analyses (e.g. Égert and Lahrèche-Revil [2003]) and panel studies (e.g. Kim and Korhonen [2002], Égert and Lommatzsch [2004] and Schularick and Bialluch [2005]). Kim et.al. [2002] employs a so-called "out-of-sample" approach, which in contrast to in-sample approaches estimates the exchange rate for other countries than the NMCs and extrapolates these results to calculate equilibrium exchange rates for the NMCs. Probably owing to the multitude of methods, no consensus has been reached regarding the real equilibrium

¹Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

²Cyprus, Estonia, Latvia, Lithuania, Malta, Slovakia and Slovenia have already joined the ERM II.

exchange rates of the NMCs and therefore, a possible under- or overvaluation of these currencies against the euro.

The nature of the empirical problem suggests that panel methods make best use of the available information, but a number of issues need to be addressed. Containing a time-series and a cross-country dimension, panel analyses use more information than a country-by-country approach. However, due to the lack of accurate data for the NMCs, creating a panel using NMCs (i.e. an in-sample analysis) appear problematic. In addition, data availability for an in-sample analysis would be from a period the NMCs were transitioning from planned to market economies. Neglecting information about this transition process in the regression could lead to biased estimations.

The present paper applies an out-of-sample panel estimation to all ten NMCs, extending work by Maeso-Fernandez, Osbat and Schnatz [2004]. Using the *behaviorial equilibrium exchange rate* (BEER), a long-run relationship between the exchange rate against the euro and economic fundamentals³ (productivity, openness, interest rates and the exchange rate regime) is estimated for a panel of 25 OECD countries, including the old EU members and other developed countries the NMCs aim to converge to.⁴ Equilibrium exchange rates are calculated by extrapolating the coefficients for the NMCs using a new procedure to calculate NMC specific constants by choosing OECD countries that are similar to a particular NMC and averaging the constants for these countries. Results are obtained for all countries except Latvia, where no constant could be calculated.

³Meese and Rogoff [1983] point out that structural models, based on fundamentals, are not better in explaining exchange rates than a random walk. However, some studies indicate that fundamentals have explanatory power for exchange rates in the long run (e.g. MacDonald [1999]).

⁴Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

The equilibrium exchange rates indicate that the NMCs are in different states of economic convergence. While Slovenia and the Czech Republic are close to their equilibrium exchange rates, the other countries are still far away from their equilibrium, especially Poland. As the NMCs, which already entered the ERM II, chose a central rate near their actual exchange rate and not their equilibrium rate, being not near the equilibrium exchange rate could be problematic for these countries. Movements towards their equilibrium would mean either violating the bandwidth and a delay in the euro adoption or a costly defending of the margins.

The paper is organized as follows: Section 2 describes the econometric method and data. Unit root and cointegration tests for panel data are applied in section 3 and 4. The actual estimation of the long-run relationship between the exchange rate and fundamentals is done in section 5, and the extrapolation to the NMCs in section 6. Section 7 provides a closer look at the countries that have already joined the ERM II. Section 8 concludes.

2 Methodology and Data

Methodologically, an out-of-sample approach can help avoiding many of the pitfalls associated with in-sample analyses. Most of the NMCs experienced a change in their economy system in the early 1990s and are in transition from a planned economy to a market economy. Reliable economic data are only available since the beginning of the transition process, but even these data must be treated with some caution. Neglecting effects of this transition can lead to biased estimations. For example, since the transition countries started with undervalued exchange rates that gradually increased during the transition process, estimating equilibrium exchange rates based on time series data for these countries, without taking this transition effect into account, would result in biased constants and overly

high exchange rates (Maeso-Fernandez et al. [2004]). Analyses with time series data for only the NMCs would suffer from this disadvantage. Furthermore, cross-country regressions are not appropriate here, as they consider only one point in time and would lead to an overly small sample of only ten data points, one for each NMC. In contrast, an out-of-sample panel approach avoids biased estimations because of transition effects and ensures a large enough sample size.

The sample contains only non-NMCs, namely 25 OECD countries, combined in a panel. These countries are used as they are not in transition and the NMCs aim at converging to the members of the European Union and leading industrialized countries. The data are on an annual basis, starting in 1973 (end of the Bretton Woods system) and going up to 2003.⁵ The regression includes the real exchange rate as dependent variable and four exogenous variables.

The real exchange rate rer (in national units per ECU/€) is calculated as the PPP exchange rate divided by the nominal exchange rate.⁶ A rise in the real exchange rate reflects an appreciation of the currency against the euro. If *purchasing power parity* (PPP) holds, the real exchange rate follows a stationary process. Standard tests indicate that the level of the real exchange rate follows a normal distribution, while the logarithm of the exchange rate does not. As test statistics are based on the normal distribution of the residuals and endogenous variable, the real exchange rate is used.

The empirical model is straightforward. The first three exogenous variables (introduced below) are common in exchange rate equations⁷ and cover the Balassa-Samuelson effect, trade effects and the impact of monetary policy, respectively, as each of these can be expected to influence the exchange rate. The fourth variable

⁵The results obtained for the NMCs in section 6 and 7 are based on data in 2003.

⁶The PPP exchange rate is defined as the price level ratio of the foreign country (in foreign currency) to the euro area (in €).

⁷e.g. Kim and Korhonen [2002] and Égert and Lommatzsch [2004].

controls for the effect of different exchange rate regimes.

Productivity (*prod*):

Productivity, defined relative to the Euro Area captures the Balassa-Samuelson effect.

$$prod = \ln(\text{GDP per employee for country } i) - \ln(\text{GDP per employee for Euro Area})$$

Differences in the productivity between countries can lead to under- or overvaluation of the exchange rate. Higher productivity in the tradable sector does not change the prices for tradable products, as long as the purchasing power parity holds, but leads to an increase in wages in this sector. This wage increase is transferred to the sector of non-tradable goods, resulting in a general increase in prices in this economy and a real appreciation of the currency. Therefore, higher productivity should increase the real exchange rate and a positive sign is expected for the coefficient of this variable.

Interest Rate (*interest*):

This variable is defined as the interest rate differential between the home country and the euro area. Higher interest rates at home than abroad lead to capital inflow and, hence, a higher demand for the home currency and an appreciation. Therefore, a positive impact of the interest rate differential on the exchange rate is expected.

Openness (*open*):

The variable *open* measures the effects of international trade on the exchange rate. It is defined as

$$open = \ln\left(\frac{\text{exports+imports}}{\text{GDP}} \text{ for country } i\right) - \ln\left(\frac{\text{exports+imports}}{\text{GDP}} \text{ for Euro Area}\right)$$

Higher imports lead to more openness (higher trade volume) for a country and, hence, a worsening of the trade balance. To counteract this effect, the currency has to depreciate, which increase the price of imports and decrease the price of

exports. But more exports can explain higher openness as well. An increase in exports can be the results of a productivity advantage, but this effect is already covered with the productivity variable.⁸ Thus, a negative sign for this variable can be expected.⁹

Exchange Rate Regime (*regime*):

After following a variety of changing exchange rate regimes, 1999 twelve European countries have become members of a currency union. The US exchange rate on the other hand has been floating since the end of Bretton Woods in 1973. To control for potential effects of the monetary regime, a regime variable is included in the model. To represent the potential range of exchange rate systems, six different regimes from a currency union (*regime*=1) at the one end to freely floating (*regime*=6) at the other end are evaluated.¹⁰

While the exchange rate regime may matter, the direction of its impact on the real exchange rate is less clear. Higher volatility of the exchange rate leads to greater uncertainty regarding the future exchange rate and should depreciate the currency. However, when most of a country's trading partners, as well as the country itself, have flexible exchange rates, it is not possible for all of them to depreciate at the same time, at least one of them has to appreciate. This might create an incentive to fix the exchange rate in order to avoid this appreciation against the trading partners, which would worsen the competitiveness and indicates a positive sign of this variable.

⁸Nevertheless, openness and not imports are chosen as explanatory variable, as the latter one would lead to endogeneity problems.

⁹As smaller countries tend to be more open than larger ones, openness may also measure size effects. However, because the size of a country is time-invariant, size effects should be captured by the constant.

¹⁰1=currency union, 2=Peg, 3=Crawling Peg, 4=Band, 5=Managed Floating, 6=Freely Floating, based on de-facto regimes by Reinhart/Rogoff [2002]. One regime variable instead of several dummies is used to increase the degrees of freedom.

Equation (1) summarizes the empirical model as well as the expected signs of the coefficients:

$$rer = \alpha + \underset{(+)}{\beta_1} prod + \underset{(+)}{\beta_2} interest + \underset{(-)}{\beta_3} open + \underset{(+/-)}{\beta_4} regime. \quad (1)$$

The estimated model is a cornerstone of the calculation of equilibrium exchange rates for the new member countries, which is done in two steps. First, the estimated coefficients for the OECD panel ($\beta_1, \beta_2, \beta_3$ and β_4) are applied to the NMCs. Then, in a second step, constants for each NMC are estimated. As discussed above, using actual data from the NMCs leads to biased results, so an indirect method is used (see chapter 6). In contrast to the first step, the calculation of the constants adds an individual aspect to the equilibrium exchange rates.

3 Panel Unit Root Tests

An important characteristic of time series data is stationarity: does a variable fluctuate around its mean or a trend or does the variable follow a random walk? Estimations with non-stationary variables require special techniques to avoid problems like spurious regression. In what follows, panel unit root tests are applied to determine if the variables follow a stationary process.

This paper employs three unit root tests, each with a different characteristic. Unit root tests are known to lack power to be able to reject the null hypothesis. Although panel unit root tests seem to do better than individual time series unit root tests, they also suffer from not having much power, suggesting the use of multiple tests. The *Breitung test* is based on a common unit root, so that the autoregressive parameter is the same for all countries. In contrast to that, the *Fisher test* allows for individual unit roots and autoregressive parameters. The

Hadri test, unlike most unit root tests including the two mentioned above, tests the null of stationarity against the alternative of a (common) unit root.

The Breitung and Fisher tests require a decision on the lags of the tested variable. For the selection of the lag length several information criteria exist (e.g. Schwartz and Akaike). Modification of these criteria lead to improved estimations of the appropriate lag length. This paper applies the *modified Akaike information criterion*, which seems to produce the best results (Ng and Perron [2001]).

Breitung t -Test

For this test the data y_{it} ($t = 1, \dots, T$, $i = 1, \dots, N$) are generated by an autoregressive process. Let \tilde{y}_{it} and $\Delta\tilde{y}_{it}$ denote the residuals from regressing y_{it} and Δy_{it} on $\Delta y_{i,t-1}, \dots, \Delta y_{i,t-p}$. Then, with an $AR(1)$ process, y_{it} and Δy_{it} can be used instead of the residuals. To avoid biased results, the test is performed for transformed variables:¹¹

$$\tilde{y}_{it}^* = \sqrt{\frac{T-t}{T-t+1}} \left[\Delta\tilde{y}_{it} - \frac{1}{T-t} (\Delta\tilde{y}_{i,t-1} + \dots + \Delta\tilde{y}_{iT}) \right] \quad (2)$$

$$\tilde{x}_{it}^* = \tilde{y}_{i,t-1} - y_{i1} - \frac{t-1}{T} y_{iT}, \quad t = 1, \dots, T-1 \quad (3)$$

The hypothesis $H_0: \rho^* = 0$ is tested against $H_1: \rho^* < 0$ in the regression

$$\tilde{y}_{it}^* = \rho^* \tilde{x}_{it}^* + e_{it}^*, \quad t = 2, \dots, T-1 \quad (4)$$

with a t -test. This test statistic follows a standard normal distribution.

This procedure, as well as the Hadri-Test discussed below, only considers common unit root processes, so that the coefficient ρ_i^* is identical for all cross section units, whereas the Fisher test allows for individual unit root processes, so that a

¹¹As shown in Nickell [1981], the estimation of the autoregressive coefficient is biased in autoregressive panel regressions with fixed effects. Breitung [2000] argues that using bias-corrected test statistics like Levin et al. [2002] or Im et al. [2003] leads to a loss of power.

different lag length for every country is possible.

Fisher Test

Maddala and Wu [1999] and Choi [2001] propose a Fisher-type test based on the p -values for all cross-sections testing for a unit root.¹² Individual unit roots will be tested with ADF tests, although other options are possible. As the p -values indicate whether the null has to be rejected or not, the aggregation of the individual p -values for all countries should indicate stationarity or non-stationarity of the panel.

Let π_i with $i = 1, \dots, N$ denote these p -values. Then the test statistic P follows a χ^2 -distribution with $2N$ degrees of freedom:

$$P = -2 \sum_{i=1}^N \ln \pi_i \sim \chi_{2N}^2 \quad (5)$$

For small values of the test statistic, the null has to be rejected.

Hadri Test

As unit root tests seem to fail to reject the null hypothesis of non-stationarity too often, the Hadri Test, in contrast to the tests above, considers the unit root under the alternative hypothesis. Based on the KPSS test for single time series, Hadri [2000] introduced a one-sided LM-test with the unit root under the alternative. The basic regression is

$$y_{it} = r_{it} + \beta_{it} + \varepsilon_{it}, \quad \varepsilon_{it} \sim Niid(0, \sigma_\varepsilon^2) \quad (6)$$

$$t = 1, \dots, T, \quad i = 1, \dots, N \quad (7)$$

whereas the time trend can be omitted. The process r_{it} is a random walk with

$$r_{it} = r_{i,t-1} + u_{it}, \quad u_{it} \sim Niid(0, \sigma_u^2) \quad (8)$$

¹²Another well-known panel unit root test with an individual process is the IPS test. However, Choi [2001] shows that the Fisher test has more power than the IPS test.

Under the null y_{it} is stationary and σ_u^2 equals zero, so that

$$H_0 : \frac{\sigma_u^2}{\sigma_\varepsilon^2} = 0 \quad H_1 : \frac{\sigma_u^2}{\sigma_\varepsilon^2} > 0$$

The resulting test statistic is

$$LM = \frac{\frac{1}{N} \sum_{i=1}^N \frac{1}{T^2} \sum_{t=1}^T S_{it}^2}{\hat{\sigma}_\varepsilon^2} \quad (9)$$

$$S_{it} = \sum_{j=1}^t \hat{\varepsilon}_{ij}, \quad \hat{\sigma}_\varepsilon^2 = \frac{1}{NT} \sum_{i=1}^N \sum_{t=1}^T \hat{\varepsilon}_{it}^2$$

whereas $\hat{\varepsilon}_{it}$ are the residuals from regressing y_{it} on a constant and a possible time trend:

$$y_{it} = r_{i0} + \beta_i t + e_{it} \quad (10)$$

Small values for the residuals and the test statistic account for stationarity, as the process y_{it} is described adequately by equation (9).

Results

The results of the unit root tests are summarized in Tables 1-4 show, that the variables are not (trend) stationary. Moreover, the variables are all integrated of order 1 ($I(1)$), as the first differences are stationary.¹³

¹³When interpreting these results, some caution is necessary. For example, non-stationarity for the real exchange rate could imply that the PPP does not hold. This outcome is contrary to some other findings for panel data (e.g Taylor and Sarno [1998] and MacDonald [1996].) Note, however, that the non-stationarity of the real exchange rate in the panel does not preclude that the real exchange rate could be stationary for single countries, or even for the entire panel within a different time span, so that the PPP hypothesis cannot be rejected in general.

Table 1

<i>rer</i>	level		first difference	
	constant	constant and trend	constant	constant and trend
Breitung H_0 : unit root	-1.886** (0.030)	1.343 (0.910)	-9.738*** (0.000)	-9.196*** (0.000)
Fisher χ^2 H_0 : unit root	61.605 (0.126)	59.633 (0.165)	383.745*** (0.000)	315.838*** (0.000)
Hadri H_0 : no unit root	11.124*** (0.000)	5.170*** (0.000)	-0.013 (0.505)	6.962*** (0.000)

*/**/** indicate significance on the 10%,5%,1%-level; p -value in parenthesis.

Table 2

<i>prod</i>	level		first difference	
	constant	constant and trend	constant	constant and trend
Breitung H_0 : unit root	2.954 (0.998)	3.031 (0.999)	-7.728*** (0.000)	-9.061*** (0.000)
Fisher χ^2 H_0 : unit root	44.900 (0.678)	44.954 (0.676)	291.545*** (0.000)	316.018*** (0.000)
Hadri H_0 : no unit root	16.799*** (0.000)	11.458*** (0.000)	5.632*** (0.000)	8.450*** (0.000)

*/**/** indicate significance on the 10%,5%,1%-level; p -value in parenthesis.

Table 3

<i>interest</i>	level		first difference	
	constant	constant and trend	constant	constant and trend
Breitung H_0 : unit root	-0.694 (0.244)	-0.098 (0.461)	-7.196*** (0.000)	-5.926*** (0.000)
Fisher χ^2 H_0 : unit root	80.145*** (0.000)	70.376** (0.030)	185.741*** (0.000)	165.900*** (0.000)
Hadri H_0 : no unit root	4.599*** (0.000)	5.667*** (0.000)	-2.213 (0.987)	2.689*** (0.004)

*/**/** indicate significance on the 10%,5%,1%-level; p -value in parenthesis.

Table 4

<i>open</i>	level		first difference	
	constant	constant and trend	constant	constant and trend
Breitung H_0 : unit root	-1.5572* (0.058)	0.152 (0.561)	-6.560*** (0.000)	-6.519*** (0.000)
Fisher χ^2 H_0 : unit root	49.439 (0.496)	57.270 (0.224)	315.310*** (0.000)	264.938*** (0.000)
Hadri H_0 : no unit root	13.648*** (0.000)	6.166*** (0.000)	-1.385 (0.917)	4.228*** (0.000)

*/**/** indicate significance on the 10%,5%,1%-level; p -value in parenthesis.

4 Panel Cointegration Tests

Taking the non-stationarity of the variables into account, the empirical analysis will employ a cointegration approach. In a cointegrated regression the endogenous and exogenous variables are $I(1)$, but the residuals are stationary and hence $I(0)$. In economic terms this implies that a long-run equilibrium exists between the real exchange rate and the exogenous variables, which resembles the concept of equilibrium exchange rates.

Again, a variety of tests can be used to test for cointegration in this regression. Prominent among those tests are the seven tests proposed by Pedroni [1999], which allow for several forms of heterogeneity: country-specific constants, coefficients and long-run variances can be estimated. As the panel analyzed in this paper includes diverse countries like Japan, Mexico and the USA, the heterogeneity offered by these tests seems to fit the heterogeneity of the panel.

Also, using Monte Carlo simulations, Gutierrez [2003] shows that the Pedroni tests have more power than the Larsson-Lyhagen-Löthgren test and slightly more power than the Kao tests for panels of the size used in this paper ($N = 25$ and $T = 31$). In addition, the tests by Pedroni provide more heterogeneity than the tests by Kao.

The basic regression of the Pedroni tests in general terms is

$$y_{it} = \alpha_i + \delta_i t + \sum_{m=1}^M \beta_m x_{m,it} + e_{it} \quad (11)$$

with $x_{it} = x_{i,t-1} + \varepsilon_{it}$ for $t = 1, \dots, T$ $i = 1, \dots, N$

where M refers to the number of exogenous variables. For the null hypothesis of no cointegration $H_0 : \gamma_i = 1$, the following regression is tested on a unit root, as

in a cointegrated relationship the residuals are stationary.

$$e_{it} = \gamma_i e_{i,t-1} + u_{it} \quad (12)$$

The Pedroni tests can be classified into two sub-groups.¹⁴ The first contains the so-called *within*-dimension statistics, where the autoregressive coefficient γ_i is pooled across countries into one coefficient γ . Consequently, the autoregressive coefficient is equal for all countries under the null $H_0 : \gamma_i = \gamma = 1$, whereas in the alternative hypothesis $H_1 : \gamma_i = \gamma < 1$. The so-called *between*-dimension statistics are based on country-specific coefficients γ_i , thereby adding more heterogeneity and leading to the hypotheses $H_0 : \gamma_i = 1$ and $H_1 : \gamma_i < 1$ for each country. All test statistics follow a standard normal distribution. Considering the lack of power of unit root tests to reject the null of non-stationarity, all seven tests are applied to increase the reliability of the results.

Table 5

Test ($H_0 : \text{no cointegration}$)	test statistics	p -value
Panel- ν -Statistic	-6.847***	1.000
Panel- ρ -Statistic	-13.997***	0.000
Panel-PP-Statistic	-45.248***	0.000
Panel-ADF-Statistic	-4.528***	0.000
Group- ρ -Statistic	1.456	0.927
Group-PP-Statistic	-8.999***	0.000
Group-ADF-Statistic	-5.014***	0.000

*/**/*** indicate significance on the 10%,5%,1%-level

Table 5 shows the test results. With the exception of the Group- ρ -Statistic and Panel- ν -Statistic, the tests indicate cointegration between the exchange rate and the exogenous variables. For small T Monte Carlo Simulations show that the

¹⁴Both sub-groups contain tests based on Dickey-Fuller and Phillips-Perron. Furthermore, there is a variance-ratio-test that belongs to the within-tests.

Panel- and Group-ADF-Test have the highest power, whereas the Panel ν - and Group- ρ -Tests often fail to reject the null hypothesis (Pedroni [2004]), which can be an explanation for the high p -values for these particular tests.

5 Estimation

To fully take into account the cointegration relationship, the *Fully Modified OLS* (FMOLS) estimation method proposed by Pedroni [2000] is used. Similar to the cointegration tests in section 4, the advantage of this estimation procedure is that it accommodates the diversity of the countries in the panel and allows for cross-sectional heterogeneity. Another advantage of this estimation approach is that it corrects for the second order bias, which can occur for fixed effects estimators and endogeneity of the exogenous variables. Also, the variables have been carefully chosen to avoid, or at least to minimize, the impact the endogenous variable has on the exogenous variables, especially regressions with exchange rates are susceptible to endogeneity problems.

Table 6

	Coefficient	p -value ¹⁵
<i>prod</i>	0.05***	0.00
<i>interest</i>	0.01***	0.00
<i>open</i>	-1.06***	0.00
<i>regime</i>	0.05***	0.00

*/**/*** indicate significance on the 10%,5%,1%-level

¹⁵Wether the exogenous variables are significant is tested with a t -statistic, that follows a standard normal distribution.

Table 6 shows the pooled coefficients for the regressors for the entire panel. The results are highly significant, and the signs correspond to the expected influence of the exogenous variables on exchange rate movements. Higher productivity leads to a real appreciation due to the Balassa-Samuelson effect. An increase in the interest rate leads to a higher demand of the home currency and, hence, an appreciation. The estimated influence of openness on the exchange rate is negative, indicating a depreciation after an increase of imports to maintain competitiveness of the home economy. In case of the exchange rate regime variable, the estimated coefficient is positive, suggesting that countries fix their exchange rate to avoid an appreciation and, thus, a decrease in competitiveness.

6 Equilibrium Exchange Rates

The results from the non-NMC-based panel can be used to calculate equilibrium exchange rates e for the NMCs. More precisely, the following equation is applied:

$$e_{it} = \alpha_i + \beta_1 prod_{it} + \beta_2 interest_{it} + \beta_3 open_{it} + \beta_4 regime_{it} \quad (13)$$

where the β -coefficients correspond to the pooled panel coefficients reported in Table 6 and country-specific constants α_i for each NMC are used. As the β -coefficients are the same for all NMCs, the constant ought to be used to incorporate an individual, or country-specific, component in the extrapolation process.

Since direct estimation of country-specific constants for the NMCs is not advisable, an indirect method has to be derived. One possibility is to employ the pooled constant for the OECD panel, but this would not lead to individual constants for the NMCs. Another possibility is to use the average of the constants only for panel countries that are similar to a NMC. To do so, *similarity* has to be defined.

The principle idea of this procedure is to determine which OECD countries show similar characteristics with regard to the exogenous variables of the exchange rate model. In a first step, the means \bar{x}_{NMC} and \bar{x}_{OECD} and standard deviations σ_{NMC} and σ_{OECD} of the exogenous variables for the NMCs and OECD countries are calculated. The next step is to compute two intervals for each exogenous variable and each NMC:

$$[(\bar{x}_{NMC} \pm a_1 \cdot \sigma_{NMC}) \pm a_1 \cdot \sigma_{OECD}]$$

$$[(\bar{x}_{NMC} \pm a_2 \cdot \sigma_{NMC}) \pm a_2 \cdot \sigma_{OECD}]$$

The parameters a_1 and a_2 are percentage points of the standard normal distribution, in this paper 1.64 and 1.96, respectively. The last step is to take the mean of the constants of OECD countries that have their exogenous variables in the intervals, which leads to the country-specific constant α_i .

The main advantage of this approach is that it takes into account the actual country characteristics of the NMCs without ignoring some of the uncertainties surrounding such an exercise. Restricting the class of similar OECD countries to, for instance, countries with exactly the same set of exogenous variables as a particular NMC would overstate the precision of the selection of country-specific constants. Considering a range of OECD countries, this range mirrors the degree of uncertainty and the importance of outliers can be limited. And varying the class of similar OECD countries taken into account expresses the uncertainty of the procedure.

Table 7 shows the actual exchange rate and the interval for the estimated equilibrium exchange rate based on the assumed values for a_1 and a_2 , respectively. For Estonia and Lithuania both intervals with a_1 and a_2 lead to the same constant, whereas for the other countries intervals of different size have been calculated.

This raises the question of whether small intervals or single values are better than large intervals. Although larger intervals increase the probability that the true value lies in this interval, they increase the number of possible equilibrium exchange rates and, therefore, reduce the information provided by this calculation. Estimating the same or very similar constants for both parameter values increases the reliability of this constant, and therefore the reliability of the equilibrium exchange rate.

The Δ -column is calculated by subtracting the actual real exchange rate from the equilibrium exchange rate, so that a negative sign means the currency has to depreciate to reach the equilibrium level, and a positive sign implies that the currency has to appreciate. Two countries, Slovenia and the Czech Republic are near their equilibrium level. Cyprus and Estonia have a medium distance to their equilibrium, whereas all other countries are still far away from equilibrium, especially Poland. Latvia is excluded from Table 7, mostly because its relative high degree of openness compared the OECD countries in the panel does not allow a meaningful match to produce a country-specific constant.

To check whether the suggested appreciation and depreciation is reasonable in economic terms, the sign of the inflation differential to the euro area (last column) is used. A real depreciation can be achieved by either a nominal depreciation, or a decrease of home prices relative to foreign prices to enhance the competitiveness of home products and raise exports. A positive inflation differential indicates overly high prices in the home country and calls for a real depreciation. With the exception of Hungary the sign of the inflation differential is in line with the suggested direction of exchange rate adjustment.

Table 7

	Actual <i>rer</i>	Equilibrium <i>rer</i>	Δ	$\text{sign}(\pi - \pi_{Euro})$
Cyprus	0.841	[0.664 ; 0.741]	[-0.100 ; -0.177]	+
Czech	0.506	[0.524 ; 0.567]	[0.018 ; 0.061]	-
Estonia	0.547	0.418	-0.129	+
Hungary	0.529	[0.833 ; 0.886]	[0.304 ; 0.357]	+
Lithuania	0.441	0.837	0.396	-
Malta	0.671	[0.174 ; 0.391]	[-0.276 ; -0.493]	+
Poland	0.467	[1.223 ; 1.478]	[0.755 ; 1.011]	-
Slovakia	0.457	[0.124 ; 0.133]	[-0.323 ; -0.332]	+
Slovenia	0.701	[0.722 ; 0.725]	[0.021 ; 0.024]	+

As the OECD panel has been identified as non-stationary, the interpretation of the mean and the standard deviation of these variables can be problematic. Therefore, to check the robustness of the results, the constants are re-estimated in a slightly different way. The same general procedure is applied, but this time using first differences, which are stationary, instead of the level of the variables based on a cointegration approach (chapter 3). This implies a different concept of *similarity*: similarity in changes instead of similarity in levels. The equilibrium exchange rates calculated with constants derived from this approach are shown in Table A1 (see appendix). These results, while not completely identical to the ones depicted in Table 7, are fairly similar, as the same countries have either a small or a large distance to their equilibrium. Furthermore, the direction of the necessary exchange rate movements to reach the equilibrium is the same for all countries.

7 Exchange Rate Mechanism II

Seven countries already joined the Exchange Rate Mechanism II and have to stay in the ERM for at least two years without revaluation of the central rate or fluctuations greater than $\pm 15\%$ around this rate, if they want to join the euro area.¹⁶ A comparison between the equilibrium exchange rates and their central rates (in real terms) and bandwidth is shown in Table 8 and Figure 1. The question is whether the (real) central rate, at which countries entered ERM II in 2004 and 2005, is sufficiently close to the actual real exchange rate; another is whether actual and central rate are compatible with the equilibrium exchange.

Table 8

	Actual <i>rer</i> <i>a</i>	Equilibrium <i>rer</i> [<i>e</i> ; \bar{e}]	central rate ¹⁷ <i>c</i>	Bandwidth $\pm 15\%$ [\underline{c} ; \bar{c}]
Cyprus	0.915	[0.664 ; 0.741]	0.916	[0.779 ; 1.053]
Estonia	0.547	0.418	0.547	[0.465 ; 0.629]
Lithuania	0.441	0.837	0.441	[0.375 ; 0.507]
Malta	0.671	[0.174 ; 0.391]	0.673	[0.572 ; 0.774]
Slovakia	0.546	[0.124 ; 0.133]	0.548	[0.466 ; 0.630]
Slovenia	0.701	[0.722 ; 0.725]	0.684	[0.581 ; 0.786]

The worst-case scenario is a strong misalignment of the exchange rate, combined with an incompatibility of equilibrium and central rate and the corresponding bandwidth. Serious difficulties for a country and the euro area may emerge. If strongly undervalued/overvalued exchange rates converge to an equilibrium outside the bandwidth surrounding the central rate, policy makers must decide between letting the exchange rate leave the bandwidth, or defending the upper

¹⁶There will be no discussion of Latvia.

¹⁷Calculated as PPP exchange rate divided by the nominal central rate.

or lower margin, against fundamental market forces.

The trade-off is not an easy one. Leaving the bandwidth violates the convergence criterion for euro area membership and would lead to at least another two years in the ERM. Defending the margins to avoid these complications results in other problems because to do so the central bank has to intervene in the foreign exchange market by buying or selling euros, which requires significant resources of euros and other currencies. Even if the central bank manages to keep the exchange rate inside the bandwidth, that misaligned rate could be the irrevocable conversion rate to the euro.¹⁸ Adopting the euro with an overvalued exchange rate could lower competitiveness and lead to real costs. On the other hand, an undervalued exchange rate could imply inflationary pressure.

The results reported in this paper indicate, that only Slovenia, which will enter the euro area in 2007, is in the ideal situation of finding its central rate, the ERM II bandwidth, and the actual rate well within the range surrounding the equilibrium exchange rate. The best case scenario is only fulfilled for Slovenia. For Cyprus and Estonia the equilibrium exchange rate is near to, but not inside, the bandwidth. Ignoring for a moment that shocks may hit these three countries during their time in the ERM, none of them should have much difficulty fulfilling this criterion for adopting the euro. The situation for Lithuania and Malta is different, however. For Malta the distance between the exchange rate band and the equilibrium rate is nearly as large as the band itself, and for Lithuania it is more than two times larger. These countries might have to deal with one or more of the problems described above.

¹⁸Although the conversion rate can be adjusted to any rate inside or outside the bandwidth, such an adjustment did not happen for any of the twelve euro area countries.

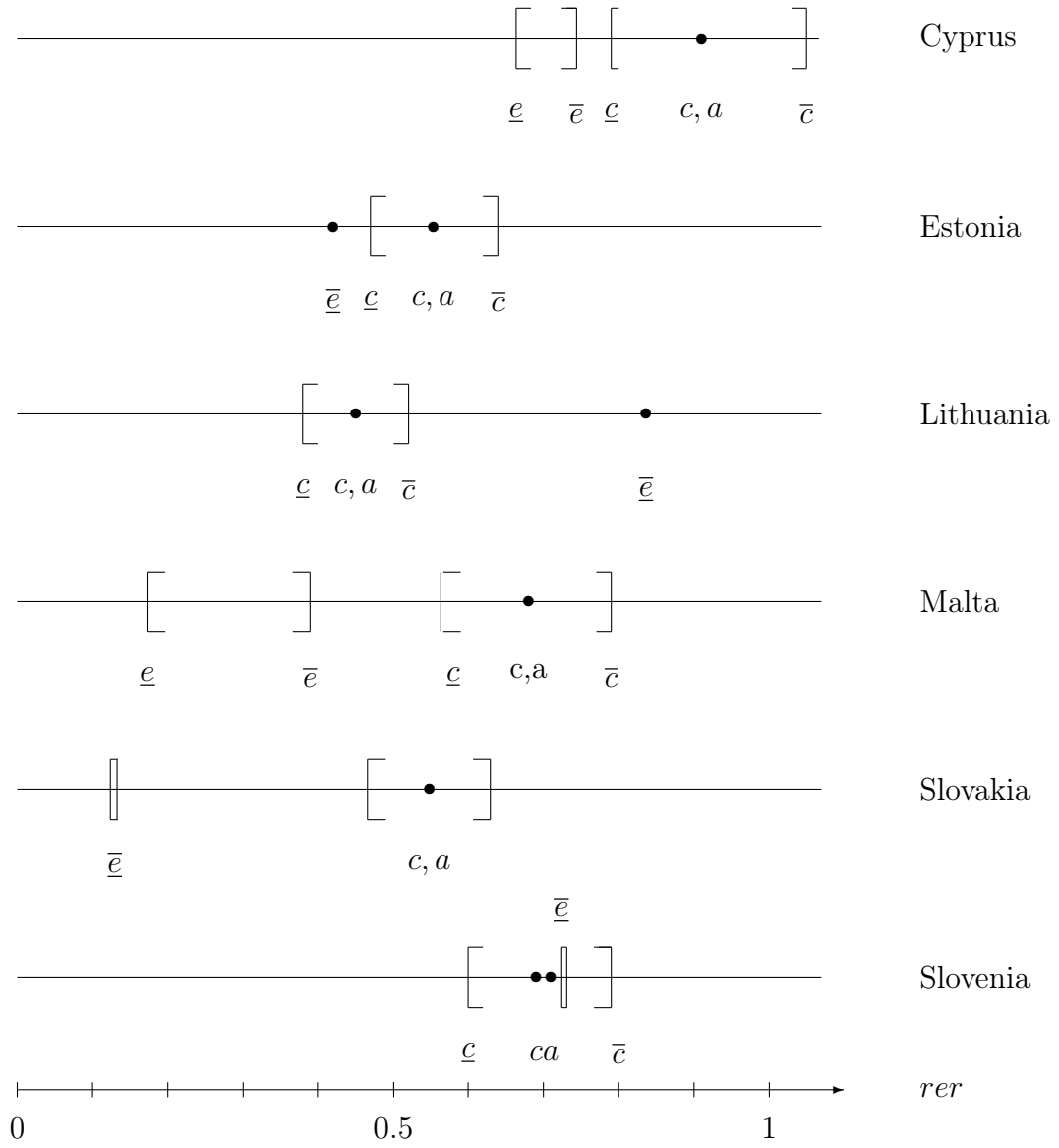


Figure 1

Notes: The equilibrium exchange rate is denoted with \bar{e} , the interval with $[e, \bar{e}]$, the actual exchange rate with a , the central rate with c and the bandwidth with $[c; \bar{c}]$.

8 Concluding Remarks

This paper estimates real equilibrium exchange rates for nine of the ten new member countries of the European Union. Equilibrium exchange rates are an indicator of transition of the NMCs. Moreover, entering the ERM II and the euro area with a central rate near the equilibrium rate is essential for a successful participation in the ERM II and the Euro Area. To avoid estimation problems due to short time-series data and the transition effects of the NMCs, an out-of-sample approach is used. A cointegrated panel of OECD countries is estimated and results for the NMCs are obtained by using the panel coefficients and calculating country-specific constants with a new method. The new Euro Area member Slovenia and the Czech Republic are close to their equilibrium. With the exception of Slovenia, the countries in the ERM II entered the exchange rate system with their equilibrium exchange rates not being in the bandwidth around their central rate. In the recent past, movements of the real exchange rate for Cyprus and Lithuania led to a convergence to their equilibrium rate, whereas Estonia, Malta and Slovakia experienced a real appreciation of their currency heading away from the equilibrium. Till now, none of them has violated the margin during their time in the ERM II. Nevertheless, Lithuania was denied a euro area entry in 2007, mainly because of high inflation rates. Therefore, an exchange rate analysis alone cannot provide sufficient evidence on convergence to the euro area. Additional criteria of the Maastricht Treaty, other macroeconomic variables and the correlation of economic shocks have to be taken into account as well. Although reaching the equilibrium exchange rate is not a guarantee that a country will be able to stay in the ERM without a necessary revaluation because of changing economic fundamentals or financial market behavior, it should make things easier.

Appendix

Data:

The Data for the exchange rates, the GDP, the GDP per employee and the imports and exports were obtained from the AMECO Database. These exogenous variables are all in current prices and Purchasing Power Standards (PPS). The long run interest rate is obtained from AMECO as well as the IFS data base. The regime dummy is based on de-facto regimes by Reinhart and Rogoff [2002].

The equilibrium exchange rates with the constants estimated with similarity in differences:

Table A1

	Actual <i>rer</i>	Equilibrium <i>rer</i>	Δ	$\pi - \pi_{Euro}$
Cyprus	0.841	0.827	-0.014	+
Czech	0.506	0.718	0.212	-
Estonia	0.547	0.294	-0.253	+
Hungary	0.529	[0.929 ; 0.939]	[0.400 ; 0.411]	+
Lithuania	0.441	0.714	0.273	-
Malta	0.671	[0.369 ; 0.393]	[-0.274 ; -0.298]	+
Poland	0.467	1.354	0.887	-
Slovakia	0.457	[0.292 ; 0.299]	[-0.158 ; -0.165]	+
Slovenia	0.701	0.812	0.111	+

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