Early Locking to the Euro: Some Estimates for the New EU Countries based on Equilibrium Exchange Rates*

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Abstract

The ECB recommends to prospective euro-area members that they choose the central parities, for fixing their currencies against the euro, consistent with a broad range of economic indicators while taking account of the market rate as well. In this paper, we estimate a behavioral model of the real exchange rates for a group of the EU 5 countries, along with equilibrium real exchange rates. In addition, we propose a methodology for estimating an *optimal* timing for ERM II entry based on convergence properties of the equilibrium real exchange rate. We find that the estimated optimal timing for ERM II entry derived from the analysis of the equilibrium real exchange rate suggests that fixing the national currencies of the EU 5 countries in forthcoming years would not be in contradiction with the convergence properties of the real equilibrium exchange rate.

Keywords: Equilibrium Exchange Rate, ERM II Entry, Time-Series Panel Data

JEL Classification: C52, C53, E58, E61, F31

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1 Introduction

Ten countries have recently joined the EU as Member States with derogation so, at some point following this accession, the new Member States will join the Exchange Rate Mechanism II (ERM II), and when they are deemed to have fulfilled the Maastricht convergence criteria they will adopt the euro. The ECB (2003) suggests that the central rate chosen by a particular country should reflect the best possible assessment of the equilibrium exchange rate at the time of entry into the ERM II. This assessment should be based on a broad range of economic indicators and developments while taking into account the market rate as well.

Both policy makers and market participants have a strong interest in finding the *equilibrium* exchange rate since the overvalued currency could lead to excessive current account deficits, rising external debt and the risk of speculative attacks. Recent empirical work concludes that an overvaluation of the real exchange rate (RER) is indeed one of the most important indicators (see Goldfajn and Valdés (1997); Kaminski, Lizondo and Reinhart (1997); IMF (1998)). Further, there is a belief that a significantly overvalued currency hinders economic growth, but that an undervalued currency has an equivocal effect on growth (Razin and Collins, 1997).

Getting some idea about what level of the exchange rate might characterise equilibrium, i.e. an internal and external balance, is therefore an important task for policy makers of the EMU accessing countries. This task is firmly associated with an identification of main fundamental determinants driving the development of the exchange rate during the final stages of the new EU countries' convergence towards the euro area. There are several theoretical frameworks that one could use as a guidance when building a model of an equilibrium exchange rate, probably the most popular being the behavioural approach, the fundamental approach (for both see e.g. Clark and McDonald, 1998) or the concept of a natural rate of the real exchange rate due to Stein (1994). A comprehensive overview of various concepts of the equilibrium exchange rate is provided by Driver and Westaway (2005).

The analysis of the real equilibrium exchange rate in this paper focuses on five countries that have recently joined the EU and are on their way to enter the ERM II - the Czech Republic, Hungary, Poland, Slovenia and the Slovak Republic (EU 5). We have excluded the remaining five countries since Cyprus and Malta are very small economies based on tourism, and the Baltic countries have been applying hard pegged regimes throughout the considered period. This makes the economies operate under different monetary policy arrangements and gives rise to different motivations for joining the ERM II and subsequently the EMU[1]. The aim herein is to propose a behavioral model of the real exchange rate suitable for the group of EU 5 countries and provide some estimates of the equilibrium exchange rate and an optimal timing for early fixing of national currencies to the euro.

Previous studies of this topic include De Broeck and Slok (2001), Fisher (2002), Kim and Korhonen (2002), MacDonald and Wojcik (2002), and Rahn (2003). They use time-series panel data estimators, sometimes in conjunction with the fixed effect model,

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[1] Even though Slovenia has joined, together with Estonia and Lithuania, the ERM II in June 2004 our related study (Komarek and Melecky, 2004) suggests that the Baltic countries are significantly different from the EU 5 group when it comes to real exchange rate modeling. Further, Slovenia appears to be conformable with the rest of the EU 5 group.

to carry out estimations of the real exchange rate models for a pool of countries including those considered in this paper. There have been some other studies involving the countries considered here, e.g. Coudert (1999), Dobrinsky (2003), and Maurin (2001). However, the latter use the pooling static panel data estimation methods. In general, the studies find that an increase in the productivity differential and an improvement in the stance of government finance are associated with a real exchange rate appreciation. The effects of the real interest rate differential, net foreign assets and the degree of openness are rather ambiguous. Our choice of countries and estimation techniques is closest to those of Kim and Korhonen (2002), MacDonald and Wojcik (2002) and Rahn (2003). However, this paper extends the latter studies in that it focus on the homogenous group of EU 5 countries, considers a broader set of determinants of equilibrium exchange rates and applies alternative estimation methods.

The paper is structured as follows. Section two summarizes recent developments in the EU 5 countries. In section three, we derive a model to estimate the behavioral equilibrium exchange rate and describe the applied estimation methods. Section four contains discussion of expected influences of selected fundamental determinants on the real exchange rate of the EU 5 countries, description of the data series, and tests for stationarity**.** In section five we carry out estimation of the proposed behavioral model of the RER. Section six includes estimation of the equilibrium real exchange rate**.** In section seven we estimate an *optimal* timing for early locking to the euro based on convergence properties of the equilibrium RER. Section eight concludes.

2 Recent Development in the EU 5 Countries

Since each of the EU 5 countries launched their transformation process at a different starting line, each had different short-term preferences regarding economic reforms and each faced a different degree of exposure to shifts in the external economic environment. The Czech and Slovak Republics started with fix-peg arrangements and narrow fluctuation bands but were forced to switch to a more flexible regime of managed floating following the turmoil of 1997. Hungary and Poland started with similar fix-peg regimes but Poland soon switched to a crawling-peg arrangement. Hungary adopted the crawling peg arrangement somewhat later, in 1995, and both countries abandoned this arrangement only recently, in 2001. Poland proceeds with managed floating, and Hungary with a fixed peg with rather wider fluctuation bands. A comparison of the real and nominal exchange rate developments in early and later stages of the transformation process are depicted in figure 1:

******* Figure 1 Here *******

All the EU 5 countries experience a strong real appreciation as a result of the excessive devaluation at the beginning of transformation and as an outcome of the transition process. The appreciation pressures brought about by the transition process occurred mainly as a result of several factors. First, domestic producers improved quality of the tradable goods which improved the terms of trade. Secondly, wages in the non-tradable sector rose slower than wages in the tradable sector. Thirdly, initial wages far exceeded productivity in the tradable sector.

All the EU 5 countries as prospective euro area members are facing the limits for their inflation rates imposed by the Maastricht inflation criteria and the inflation target of the ECB. Higher inflation is expected in countries with low price levels, i.e. all the countries except Slovenia, and faster economic growth relative to the current euro area members. A comparison of the inflation rates and prices in the EU 5 countries with the current euro area members (EU 15) is provided in figure 2:

******* Figure 2 Here *******

It is apparent from figure 3 below that growth of real GDP has been higher in all the EU 5 countries than in the euro area, maybe with slight exception of initial growth in the Czech Republic. Expressing the growth rates in terms of the future common currency accentuates the difference even more. A comparison of real GDP per capita then shows that the less developed countries are growing much faster.

******* Figure 3 Here *******

3 Theory

The estimation of the equilibrium real exchange rate carried out in this paper follows the methodology of the behavioral equilibrium exchange rate (BEER) concept. We thus start building the model for estimation using an equation for the actual real exchange rate based on the real uncovered interest parity (UIP) (for some preliminary steps see e.g. Clark and McDonald, 1998):

$$q_t = E_t\left(q_{t+k}\right) - \left(r_t - r_t^*\right) + \omega_t \tag{1}$$

where q_t is the actual RER, r_t and r_t^* are the domestic and foreign real interest rates with a maturity $t+k$, $E_t\left(q_{t+k}\right)$ is the conditional expectation of the $t+k$ period real exchange rate and ω_t is the time-varying risk premium. Further, $r_t = i_t - E_t\left(\pi_{t+k}\right)$, is the *ex ante* real interest rate, where i_t is the nominal interest rate with a maturity $t+k$ and $E_t\left(\pi_{t+k}\right)$ is the conditional expectation of inflation, π_t, in period $t+k$. An increase in the risk premium is postulated to induce a depreciation of the RER which, given the model, generates an expected appreciation. The risk premium can be written out in full as:

$$\omega_t = \mu + \lambda_t + e_t \qquad (2)$$

where μ is a constant, λ_t is some proxy for the unobserved risk premium and e_t is a white noise. The proxy is assumed to be a negative function of the cumulative current account balance-to-GDP ratio $\sum_1^t ca_t / gdp_t$:

$$\lambda_t = f^+\left(\sum_1^t ca_t / gdp_t\right) \qquad (3)$$

hereafter the function $f(\cdot)$ is restricted to be linear. For instance, an increase in the cumulative current account deficit increases the risk premium on the domestic currency and induces a depreciation of the current real exchange rate.

Considering again equation (1), the conditional expectation is also restricted to be a linear function of an information set that we will condition upon. One important issue is that we are looking at countries in transition from emerging markets to developed economies. It is therefore useful to decompose the expectation, assuming it is linear, into two parts:

$$E\left(q_{t+k} \mid I_t\right) = E\left(q_{t+k} \mid I_t^*\right) + E\left(q_{t+k} \mid I_t^T\right) \qquad (4)$$

where I_t^* involves the traditional determinants of RER of developed economies (see e.g. McDonald, 1997), and I_t^T is a set of determinants that are effective only during transition periods and their effect on the RER ceases to be significant as the countries accomplish their transitions. Applying the assumption of linearity and using equations (2)-(4), (1) can be expressed as:

$$q_t = \mu + \theta_1 X_{1,t} + \theta_2 X_{2,t} + \theta_4 \left(r_t - r_t^*\right) + \theta_4 \left(\sum_1^t ca_t / gdp_t\right) + e_t \qquad (5)$$

where $X_{1,t}$ is a subset of I_t^* and similarly $X_{2,t}$ is a subset of I_t^T, θ_1 is expected to be non-zero, $\theta_2 \rightarrow 0$ as t approaches the end of the transition period, θ_4 is expected to be equal to one if real UIP holds, and θ_4 is expected to be positive.

Since T (the number of observations for each country) is substantially greater than N (the number of cross-section units) the model described by (5) is estimated using a method suitable for time-series panel data. There are essentially two procedures applied to time-series panels. At one extreme, we can estimate each equation separately for each country and then examine the distribution of the estimated coefficients across countries where the mean or the median would be of the main interest. However, such an estimator does not take into account possible homogeneity of some coefficients across countries. At the other extreme are the traditional pooled estimators, e.g. fixed effect estimator, which allow the intercepts to vary across countries while constraining all the other coefficients, including the error variance, to be the same.

We use here the pooled mean group (PMG) estimator, proposed by Pesaran, Shin and Smith (1999), as it involves both pooling and averaging and thus introduces a great deal of flexibility. This estimator allows the intercept, short-run coefficient, and error variance to vary in unconstrained manner across countries, but at the same time constrains the long-run coefficients to be the same. Thus given the data on time periods $1,2,...,T$ and countries $1,2,...,N$ we want to estimate an $ARDL(p,q,q,...,q)$ model. If we reparameterise the model in (5) as in Pesaran, Shin and Smith and stack the time-series observation for each country then (5) can be written as:

$$\triangle \boldsymbol{q}_i = \phi_i \boldsymbol{q}_{i,t-j} + \boldsymbol{X}_i \boldsymbol{\beta}_i + \sum_{j=1}^{p-1} \alpha_{i,j}^* \triangle \boldsymbol{q}_{i,-j} + \sum_{j=0}^{q-1} \triangle \boldsymbol{X}_{i,-j} \boldsymbol{\delta}_{i,j}^* + \mu_i \boldsymbol{\iota} + \boldsymbol{\varepsilon}_i \qquad (6)$$

where $i = 1,2,...,N$, $\boldsymbol{q}_i \equiv (q_{i1},...,q_{iT})'$ is a $T \times 1$ vector of observations on the RER of the i-th country, $\boldsymbol{X}_i \equiv \left[X_{1i} \quad X_{2i} \quad r_i - r_i^* \quad \sum_1^t ca_t / gdp_t \right] \equiv (\boldsymbol{X}_{i1},...,\boldsymbol{X}_{iT})'$ is a $T \times k$ matrix of observations on the determinants of the RER that vary both across countries and time periods, $\boldsymbol{\iota} \equiv (1,...,1)'$ is a $T \times 1$ vector of ones, $\triangle \boldsymbol{q}_{i,-j}$ and $\triangle \boldsymbol{X}_{i,-j}$ are the j-period lagged values of $\triangle \boldsymbol{q}_i \equiv \boldsymbol{q}_i - \boldsymbol{q}_{i,-1}$ and $\triangle \boldsymbol{X}_i \equiv \boldsymbol{X}_i - \boldsymbol{X}_{i,-1}$, respectively, and $\boldsymbol{\varepsilon}_i \equiv (\varepsilon_{i1},...,\varepsilon_{iT})'$ is a $T \times 1$ vector of residuals. There are a number of assumptions underlying this model and we outline only several of them that are of a practical nature. First, the disturbances ε_{it} are independently distributed across i and t, and are independent of the regressors, i.e. $E(\boldsymbol{\varepsilon}_i \mid \boldsymbol{X}_i) = 0$. Second, the underlying $ARDL(p,q,q,...,q)$ model is stable, which ensures that $\phi_i < 0$ and hence there exists a long-run relationship between $q_{i,t}$ and $X_{i,t}$ defined as:

$$q_{i,t} = -(\boldsymbol{\beta}_i' / \phi_i) X_{i,t} + \eta_{i,t} \qquad (7)$$

where $\eta_{i,t}$ is a stationary process. Third, the long-run coefficients on $X_{i,t}$, defined by $\boldsymbol{\theta}_i \equiv -\boldsymbol{\beta}_i' / \phi_i$, are the same across countries, i.e. $\boldsymbol{\theta}_i = \boldsymbol{\theta}$. Under the assumptions the model in (6) can be written in a more compact form as:

$$\Delta \boldsymbol{q}_i = \phi_i \boldsymbol{\xi}_i(\boldsymbol{\theta}) + \boldsymbol{W}_i \boldsymbol{\kappa}_i + \boldsymbol{\varepsilon}_i \tag{8}$$

where $\boldsymbol{\xi}_i(\boldsymbol{\theta}) = \boldsymbol{q}_{i,-1} - \boldsymbol{X}_i \boldsymbol{\theta}$ is the error-correction component, and the definition of $\boldsymbol{W}_i$ and $\boldsymbol{\kappa}_i$ is obvious from a comparison of (6) and (8). The country specific equations are thus non-linear in ϕ_i and $\boldsymbol{\theta}$. Further, the error variance $var(\varepsilon_{i,t}) \equiv \sigma_i^2$ is allowed to vary across countries. Assuming that the disturbances $\varepsilon_{i,t}$ are normally distributed the concentrated log-likelihood function is:

$$l_T(\boldsymbol{\varphi}) = -\frac{T}{2}\sum_{i=1}^{N} \ln 2\pi\sigma_i^2 - \frac{1}{2}\sum_{i=1}^{N} \frac{1}{\sigma_i^2}\left(\Delta \boldsymbol{q}_i - \phi_i \boldsymbol{\xi}_i(\boldsymbol{\theta})\right)' \boldsymbol{H}_i \left(\Delta \boldsymbol{q}_i - \phi_i \boldsymbol{\xi}_i(\boldsymbol{\theta})\right) \tag{9}$$

where $\boldsymbol{H}_i \equiv \boldsymbol{I}_T - \boldsymbol{W}_i \left(\boldsymbol{W}_i' \boldsymbol{W}_i\right)^{-1} \boldsymbol{W}_i'$. $\boldsymbol{\varphi} \equiv \left(\boldsymbol{\theta}' \quad \boldsymbol{\phi}' \quad \boldsymbol{\sigma}^2\right)$ where $\boldsymbol{\sigma}^2 \equiv \left(\sigma_1^2, \sigma_1^2, \ldots, \sigma_N^2\right)$.

Maximum likelihood (ML) estimation of the long-run coefficients, $\boldsymbol{\theta}$, and the country-specific error-correction coefficients, ϕ_i, can be computed by maximizing (9) with respect to $\boldsymbol{\varphi}$. These ML estimators (MLE) are termed PMG estimators to emphasize both the pooling implied by the homogeneity restrictions on the long-run coefficients and the averaging across countries used to obtain means of the estimated error-correction coefficients and the other short-run coefficients of the model.

4 RER Determinants, Data Description and Unit Root Tests

In this section we present the explanatory variables chosen to model the real exchange rate. The selection has been made in accord with the findings of the previous studies (see section 1), and data availability and reliability. We start by looking into expected impacts of the variables and provide a description of data series used, before testing the degree of integration of the stacked series of each variable.

4.1 Determinants of the Real Exchange Rate

Productivity Differential

Productivity differential (dpro) - the differential between productivity in the EU 5 countries and Germany calculated as the ratio of real GDP over employment in both countries.

A higher average productivity in the domestic relative to the foreign economy is typically expected to result in an appreciation of the domestic currency mainly due to higher domestic inflation as a result of faster productivity growth. This channel is traditionally associated with the Balassa-Samuelson effect. Assuming perfect labor mobility the latter effect tells us that if the productivity growth in the domestic tradable sector (manufacturing) is relatively higher than in the non-tradable sector (services) the wages in the tradable sector tent to increase. The perfect labor mobility equalizes the wages in both sectors and increases prices of the non-tradable goods hence increasing the overall price level in the domestic economy with respect to the foreign economy. The appreciation can however be materialized through the nominal exchange rate as well, as the increase productivity implies higher economic growth and higher demand for the domestic currency relative to the foreign currency.

Terms of Trade

Terms of trade (tot) - the ratio of export and import price indices in each economy.

A positive shock to the terms of trade, e.g. an increase in prices of exported goods, is assumed to generate two effects. A *substitution effect* when the domestic production sector shifts the production towards tradable (exportable) goods resulting in higher wages in the tradable sector relative to the non-tradable sector. The wages equalize subsequently due to sufficient labor mobility inducing an increase in the overall domestic price level. The improvement in the current account and the higher domestic price level make the domestic currency appreciate. The *income effect*, on the other hand, comes about as the improvement in the trade balance raises income of the domestic economy and higher demand for the non-tradable goods emerges. To restore the internal equilibrium the real exchange rate is required to depreciate. The relative magnitudes of the substitution and income effects hinge on relative price elasticity of the demands for imports and exports.

Net Foreign Assets

Net foreign assets (nfa) - the ratio of net foreign assets relative to nominal GDP, both denominated in a national currency.

The balance-of-payment logic postulates that the current account deficits cumulate up to net foreign liabilities with associated dividends and rental payments. The interest has to be paid for by an improvement in the trade balance. This requires the currency to depreciate, thus increasing the international price competitiveness of the country's exports. On the other hand, the portfolio balance reasoning may require opposite adjustment of the real exchange rate. The countries debt as a result of current account deficits has to be financed by internationally diversifying investors. To adjust they portfolio in the desired way they require a higher yield. With given interest rates the higher yield is achieved through an appreciation of the debtor country's currency.

Degree of Openness

A measure of openness (open) **-** the ratio of the sum of exports and imports relative to nominal GDP, all denominated in national currencies.

A relatively higher degree of openness predisposes a given country to more efficient transfers of knowledge and technology either in a direct or indirect form. It also enables the country to benefit from its comparative advantages to a higher degree. One can also argue that the country risk is positively related to the degree of openness since the country would suffer a significant loss by loosing its international connections. This variable can be viewed as corresponding to the transition bit of the real exchange rate dynamics since one would expect that a developed country experience only limited variation in its degree of openness.

Foreign Direct Investment

Foreign direct investment (fdi) - the ratio of the net foreign direct investment over nominal GDP calculated from four quarters moving averages, both denominated in a national currency.

The FDI inflow is expected to increase average productivity and eventually result in a domestic currency's appreciation. The effect of the FDI through the financial account works along the same lines. Namely, higher supply of foreign currency as a consequence of the FDI inflow induces a nominal appreciation of the domestic currency. In the long run, however, the current account deficit resulting from the factor payments on the productive FDI makes the currency depreciate as the debt grows. This variable has a substantial effect on the development of the real exchange rate in emerging market economies where the FDI flows are indeed substantial.

Real Interest Rate Differential

Real interest rate differential (dlr) **-** the differential between Czech and German lending rates deflated by Czech and German inflation rates, respectively.

An inclusion of the real interest rate differential is well justified by the BEER approach that derives the real exchange rate model from the underlying UIP the real interest rate differential is a part of. According to UIP, the currency with a positive interest rate differential is expected to depreciate so as to equate the yields in domestic and foreign currencies. The latter is required to eliminate any possible arbitrage opportunity. On the other hand, an increasing interest rate differential induces portfolio reallocation and higher demand for the currency with a relatively higher interest rate. This two opposite forces may result in an ambiguous impact of the interest rate differential on the exchange rate, even though, the theory underlying BEER is unequivocal in this respect.

Cumulative Current Account Balances

Current account (ca) - the cumulative current account deficit relative to nominal GDP, both denominated in national currencies.

The cumulative current account balances with respect to GDP are common indicators of external imbalance and provide early-warning signals about external crises (see Kaminsky, Lizondo and Reinhart, 1997). It is also used as an approximation of foreign indebtedness of a country implying higher debt servicing and a currency's risk premium.

Quarterly data are used covering the period from the first quarter of 1994 to the first quarter of 2004. The time series are transformed into logarithms except for those expressed as a ratio to nominal GDP and the real interest rate differential. The relevant series are seasonally adjusted using the X12 procedure or the Tramo/Seats method. The data are obtained from the IFS, Eurostat and New Cronos databases. The dependent variable is *the real exchange rate (rer)* constructed as an index of the nominal exchange rate against DEM (EUR) deflated by the consumer price index (CPI) for a given country and Germany (EMU). A decrease of this index denotes a real appreciation of the real exchange rate.

4.2 Unit Root Tests

To test the order of integration of the series later analyzed as a panel we adopt several tests recently developed by Levin, Lin and Chu (2002), Breitung (2000), Maddala and Wu (1999) and Choi (2001), and Hadri (1999). We focus on and report the result of the Levin, Lin, Chiu and Fisher-type ADF tests first and then if the conclusions are indecisive draw some further insights from the Breitung's t-test and the Hadri's z-test. A combination of tests is useful in this instance with regard to different construction of the tests[2]. The acquired results for the series to be used in estimation are reported in table 1:

******* Table 1 Here *******

The applied unit root tests deliver a clear evidence of non-stationarity of the cumulative current account to GDP ratio, the productivity differential, the foreign direct investment to GDP ratio, net foreign assets to GDP ratio, the measure of the degree of openness and the terms of trade. Although the results of the unit root tests reported in table 1 may seems to provide clear cut answers regarding the degree of integration of the remaining series a few comments should be made in this regards. Starting with the series of real interest rate differentials where the Breitung t-statistic and the Hadri z-statistic take values of 0.4932 [0.6891] and 7.5363 [0.0000], respectively, suggesting presence of a unit root process in the series. Regarding the series of the real exchange rate, the corresponding Breitung t- and the Hadri z-statistics are 3.6691 [0.9999] and 11.2170

[2] The Levin, Lin, Chiu's test has the null hypothesis of common unit root and restricts the tested coefficients of the transformed variables in the final ADF regression to be common across countries. The Fisher-type ADF test is based on calculation of a weighted average of the country specific coefficients from the basic ADF regressions. In addition, Hadri's z-test takes the null hypothesis of no unit root in any of the time series in the panel and is, similarly as the more familiar KPSS test, based on the LM statistic for the residuals from a simple regression of a series on the deterministic components.

[0.0000] suggesting that the *rer* series have unit root processes in them[3]. We thus treat the variable as integrated to order I(1).

5 Estimation

Estimation of the model for the real exchange rate developed in section 2 is carried out using the MGE and the PMGE methods described above. Namely, we regress the real exchange rate, *rer*, on the variables *dprod*, *ca*, *fdi*, *nfa*, *open*, *tot*, and *dlr*. When interpreting the estimation results we focus mainly on the pooled (joint) outcome for the panel of countries under consideration. The individual results are reported as supplements and are not dicussed in detail.

5.1 Mean Group Estimation

The mean group (MG) estimates of the model help us in examination of how compatible are the restrictions imposed by PMG estimator with the data. At first a decision regarding how many lags of a given variable are going to be included in the model has to be made for each country. We restrict the maximum lag to be one but the acquired results proved to be reasonably robust to the considered lag length. The lag length selection is based on the Akaike Information Criterion (AIC) although some alternatives

[3] We carry out the battery of test for the *rer* series again this time with individual effect and liner trends but no further insights are gain and the conclusions are similar.

are available, such as Bayesian Information Criterion (BIC)[4]. The model selection results using AIC are reported in Table 2:

******* Table 2 Here *******

We first estimate the ARDL model with given lag lengths for each variable and country using the MGE, i.e. leaving the long-run coefficients unrestricted and looking at the distribution of those coefficients across the countries. The main interest is in the mean of this distribution, however, we calculate the median as well for comparison. The estimation results are reported in Table 3:

******* Table 3 Here *******

We report the individual estimation results mainly for completeness and will use it as a reference material when discussing the PMG estimates. The first column of table 3 shows the coefficients on the lagged dependent variable, which is the coefficient ϕ in equation (8). A check on whether the variables for each country cointegrate is to look at the estimates of the ϕ coefficient which should be significantly different from zero and negative if cointegration is present. One can thus see that the conitegration is only weak in the case of the Slovak Republic. Exclusion of the Slovak Republic does not change the results and we proceed by keeping it in our pool of countries.

Consider next the distributions of the coefficients estimates for each determinant of the real exchange rate. The plots of histograms of the coefficients estimates for each

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[4] We prefer AIC over BIC since the former is not as strict about the information content of a particular variable as the BIC. For this reason AIC tends to include relatively longer lag length for a given variable. However, using BIC did not have any significant implications for the estimates.

variable, kernel estimates of their distributions and normal densities are shown in figure 4:

******* Figure 4 Here *******

The densities seem to be well shaped, however, some observation can be made. The first is associated with the coefficients on the real interest rate differential where the coefficient distribution resembles rather uniform then normal density, leaving us with not much of a conclusion regarding the expected effect of the *dlr* variable. The peaks of the coefficient densities for *ca* and *dpro* variables are well concentrated around zero. The effect of *fdi* is well concentrated around negative one which is consistent with the theory so that net FDI inflows make the domestic currencies appreciate. The MG estimate of the positive impact of the degree of openness on the RER is mainly determined by the results for the Czech Republic, Poland and the Slovak Republic. In this case Hungary and Slovenia are rendered some prior information from the latter countries. The same remark is applicable to the density of coefficients on the productivity differentials where the significant information about the overall negative effect is delivered by the Slovak Republic and Hungary. This effect is again consistent with our expectations that positive productivity differential induces a currencies' appreciation. Finally, the MG coefficient estimate of the terms of trade is positive mainly due to estimates for Hungary, Poland and the Slovak Republic.

The associated diagnostics for each country are computed, namely, the Godfrey's test of residual serial correlation, the White test of heterosckedasticity, both distributed as chi^2 with one degree of freedom and the Jarque-Bera's test of normality, also chi^2 but with two degrees of freedom. The diagnostics of the MG estimation for the EU 5 countries seem to be satisfactory. The results of the tests are reported in table 4:

******* Table 4 Here *******

5.2 Pooled Mean Group Estimation

We now present the results obtained when we estimate the proposed model of the real exchange rate using the PMG estimator described in section 3.

******* Table 5 Here *******

The PMG estimate of the *ca* coefficient is significantly negative, suggesting a currency's depreciation in reaction to an increase in the cumulative current account-to-GDP ratio, a result in contradiction to our theoretical reasoning. The effect of the net FDI is estimated to be negative, again in line with the theory, but this time insignificant. The coefficient of the real interest rate differential is insignificant and so are those of the net foreign assets and the measure of openness. The significant negative impact of the productivity differential on the RER is again estimated with high precision. The effect of the terms of trade is positive and significant as in the MG case accentuating dominance of the income effect over the substitution effect of the terms of trade in the medium to long run.

The residual diagnostics, namely, the test for autocorrelation, normality and heteroscedasticity are reported in table 6 together with the estimates of the ϕ coefficient and the adjusted R squares.

******* Table 6 Here *******

The diagnostics reveal some problems with heteroscedastic residuals, namely in the case of the Czech Republic, Slovenia and possibly Poland, and highly non-normal distributions of the residuals for the Czech Republic and Slovenia. However, the major concern is the failure of getting any fit for all countries apart from Poland and the fact that the variables in the case of the Czech Republic, Slovenia and possibly Slovak Republic fail to cointegrate. Due to this unfavorable behavior of the PMG estimates we shall proceed hereafter by using the MG estimator.

6 Modeling the Equilibrium RER

As described in (1) the long-run equilibrium exchange rate is defined as $E_t\left(q_{t+k}\right)$ so that the short-run part is the one associated with the interest-rate differential and the risk premium and the UIP shock. Concatenating the variables producing the estimate of the systematic short-run component to a vector Z_t and those producing the long-run component to a vector Y_t enable us to write (5) as:

$$q_t = \gamma_1 Y_t + \gamma_2 Z_t + e_t \tag{10}$$

Thus the long-run equilibrium RER according to the BEER model can be estimated in two steps using the Frisch-Waugh-Lovell (FWL) theorem. First, we orthogonalize both q_t and Y_t with respect to Z_t and then estimate the following regression to isolate the non-systematic component e_t:

$$M_Z q_t = M_z Y_t \gamma_1 + e_t \tag{11}$$

where $M_z = I - Z(Z'Z)^{-1} Z$ is the idempotent matrix. The vectors $M_Z q_t$ and $M_Z Y_t$ are obtained by applying MGE to the corresponding ARDL model. In table 7 we present the estimation of projections of the Y_t variables in to the plane spanned by the Z_t variables. This is done by isolating the effect of the real interest rate differential and the cumulative current account balances on the determinants of the equilibrium exchange rate, i.e. *fdi*, *open*, *dprod*, *tot*, and the real exchange rate, *rer*.

******* Table 7 Here *******

Now, we construct the variables described in equation (11) so that one can estimate the equilibrium real exchange rate as defined by the BEER approach. The estimation results for equation (11) using the MG estimator are reported in Table 8:

******* Table 8 Here *******

The projections of fdi_t and nfa_t bear a similar sign to the full model estimates where the former variable now have a coefficient that is about five times large in its magnitude. The projections of $open_t$, $dpro_t$ and tot_t bear opposite signs to those acquired when the full model is estimated. The $M_Z open_t$ variable appears to be rather insignificant. The effect of the adjusted productivity differential is significantly positive, suggesting that after being filtered of the effects of interest rates and current account balances, the differential impacts on the adjusted RER in a manner consistent with a consumption differential rather then productivity. Similarly, the adjusted tot_t variable has now a significant negative effect on the adjusted RER implying that the performed projections emphasize propagation of the substitution effect of the terms of trade. The estimate of the BEER is thus described by the following equation:

$$\widehat{E_t\left(q_{t+k}\right)} = -5.87 M_Z fdi_t - 0.27 M_Z nfa_t - 1.24 M_Z open_t - 1.46 M_Z dpro_t - 0.20 M_Z tot_t \quad (12)$$

7 Optimal Timing for Early Locking to the Euro

In this section we attempt to provide some estimates of the stage at which the EU 5 countries should be ready to joint the ERM II, from the RER perspective. This estimation, however, does not attempt to provide any normative recommendation about at what moment should any of the countries joint the ERM II since it is restricted to focusing on the indications coming from the real exchange rate only.

The economic theory suggests that countries in transition catching up with developed economies should experience an appreciation trend in the real exchange rate that is dying out as a higher degree of convergence is achieved. Some evidence of such a development may be observed in figure 1. The Baltic countries are considered as well to obtain a general support for this argument. An optimal timing for ERM II entry is then associated with a requirement of exchange rate stability, i.e. the exchange rate is required to fluctuate within a narrow band and about a long-run equilibrium that is steady.

******* Figure 5 Here *******

Now, let us assume the countries have an incentive to joint the ERM II as soon as possible, i.e. in our framework when the exchange rate is not fluctuating about its trending equilibrium but an equilibrium that is constant. Given the observed dynamics of the average real exchange rate one can think of expressing the convergence trajectory of the equilibrium exchange rate as[5]:

[5] There are some other functions that would be suitable for an approximation of the RER trajectory, the main candidates being logarithmic and exponential functions. However, given the purpose of our exercise the quadratic function appears to be the most convenient.

$$E_t\left(q_{t+k}\right) = at + bt^2 \tag{13}$$

where a and b are estimated coefficients, and t is the time trend. The estimates of a and b are expected to bear negative and positive signs, respectively.

The objective (loss) function[6] of any EU 5 country can be written as:

$$\min\left|E_t\left(q_{t+k}\right) - q_t\right| \tag{14}$$

This objective function postulates that a country wants to minimize the magnitude of fluctuations of the actual exchange rate from the equilibrium one. Given the countries incentive to joint the ERM II as soon as possible the optimum timing for doing so can be obtain from the following minimization:

$$\underset{t \in R^+}{\arg\min}\left|E_t\left(q_{t+k}\right) - q_t\right| \text{ st. } E_t\left(q_{t+k}\right) = at + bt^2 \tag{15}$$

where it is assumed that $a < 0$ and $b > 0$. Since $\widehat{E_t\left(q_{t+k}\right)}$ is obtained from $\min\sum_{t=1}^{T}\hat{v}_t^2$ where $\hat{v}_t = q_t - \hat{\delta}Z_t - \widehat{E_t\left(q_{t+k}\right)}$ and only $\widehat{E_t\left(q_{t+k}\right)}$ is assumed to be a function of the time trend this minimization is analogous to:

$$\underset{t \in R^+}{\arg\min}\,\widehat{E_t\left(q_{t+k}\right)} = at + bt^2 + \varepsilon_t \tag{16}.$$

Following (16) we first regress $\widehat{E_t\left(q_{t+k}\right)}$ on the linear and quadratic trends to get estimates of a and b. The results are shown in table 9:

******* Table 9 Here *******

The first order condition for (16) is:

$$\frac{\partial\left(\hat{a}t + \hat{b}t^2\right)}{\partial t} = -\hat{a} + 2\hat{b}t = 0 \tag{17}$$

[6] The absolute value loss function can also be replaced here by the quadratic given the argumentation below. However, we keep it as absolute value to make the exposition of our reasoning simple.

The optimum t, t^*, is then obtained from:

$$t^* = \frac{\hat{a}}{2\hat{b}} \tag{18}$$

which can be viewed as a simple estimator of an optimal timing for ERM II entry based on the convergence properties of the equilibrium exchange rate. The estimates of the optimal t are shown in table 10[7]:

******* Table 10 Here *******

The estimate of the optimal timing based on the equilibrium RER shown in table 10 seems to suggest that, at present, fixing the national currencies to the euro would not be in contradiction with the joint convergence of the equilibrium RER in the EU 5 countries as a group. Such an outcome should not be interpreted as a recommendation per se, but may serve as some guidance and contribute to a much broader discussion.

8 Conclusion

Recently, eighth post-socialist countries have joined the EU following the path towards full integration into the EMU. The Baltic countries already entered the ERMII fixing their exchange rates to the chosen parities. For the other countries and their successors in the process of integration the choice of the optimal parity is still ahead. An important guide on what exchange rate level might be appropriate for fixing can be derived from

[7] When constructing the confidence intervals we keep the estimate of the coefficient attached to the quadratic time trend as fixed and account for the randomness in the coefficient attached to the linear trend. We treat the former coefficient estimate as fixed as it converges to its true value at much faster rate than the latter estimate. Namely, the coefficient attached to the linear trend has asymptotic convergence of order $o\left(T^{3/2}\right)$ whereas the coefficient of the quadratic trend $o\left(T^{5/2}\right)$.

an analysis of the equilibrium exchange rate. In this paper, we have estimated a behavioral model of the real exchange rates for the group of the EU 5 countries and attempted to deliver estimates of the equilibrium real exchange rate. In addition we have proposed a methodology for estimation of an optimal timing for early entry of the ERM II based on the convergence properties of the equilibrium real exchange rate. Such estimates may contribute to a broad discussion on the optimal timing for ERM II entry and conversion of the national currencies to the euro.

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Tables

Table 1: Panel Data Unit Root Tests

Test	Levin, Lin, Chiu		Fisher ADF	
Variable	levels	differences	levels	differences
ca	0.6036 [0.7270]	-3.4536 [0.0003]	3.1224 [0.9998]	35.9486 [0.0029]
dpro	0.9211 [0.8215]	-9.6240 [0.0000]	2.7617 [0.9999]	153.638 [0.0000]
fdi	2.0607 [0.9803]	-14.2458 [0.0000]	17.5123 [0.3532]	246.308 [0.0000]
dlr	-1.1862 [0.1178]	-28.9963 [0.0000]	37.1708 [0.0020]	511.820 [0.0000]
nfa	-1.1987 [0.1153]	-14.1572 [0.0000]	9.6942 [0.8821]	225.492 [0.0000]
open	-0.3896 [0.3484]	-12.9958 [0.0000]	33.5411 [0.0063]	213.575 [0.0000]
rer	-15.2708 [0.0000]	-11.6158 [0.0000]	128.963 [0.0000]	173.651 [0.0000]
tot	-1.3653 [0.0861]	-19.8120 [0.0000]	46.7497 [0.0001]	537.452 [0.0000]

Note: The Levin, Lin, Chiu test is distributed as a standard normal and assumes a common unit root process as the null, the Fisher ADF test is distributed as chi^2 and assumes that under the null the series have individual unit root processes in them. The associated p-value is in the square brackets.

Table 2: Lag Length Selection Based on AIC

	rer	ca	fdi	rir	nfa	open	dprod	tot
Czech Republic	1	0	0	0	1	0	1	0
Hungary	1	0	0	0	0	0	0	0
Poland	1	0	0	1	1	1	0	0
Slovenia	1	0	0	0	0	0	0	0
Slovak Republic	1	1	0	1	0	0	0	0

Table 3: Estimation Results for Individual Countries and the MG Estimates

Group	phi	ca	fdi	dlr	nfa	ope	dpro	tot	constant
Czech Republic	-0.467 (0.122)	0.328 (0.053)	-1.028 (0.395)	0.025 (0.007)	-0.219 (0.111)	0.621 (0.159)	-0.539 (0.474)	0.028 (0.011)	3.193 (1.078)
Hungary	-0.312 (0.126)	-0.255 (0.157)	-0.876 (0.767)	-0.009 (0.008)	0.089 (0.168)	-0.055 (0.147)	-2.559 (0.853)	3.340 (1.050)	0.249 (1.915)
Poland	-0.300 (0.112)	-0.026 (0.082)	-2.773 (2.646)	0.005 (0.010)	-0.636 (0.585)	0.903 (0.720)	-1.362 (1.387)	0.879 (0.586)	2.025 (1.769)
Slovenia	-0.602 (0.097)	-0.111 (0.065)	0.434 (0.256)	0.002 (0.001)	-0.158 (0.038)	-0.129 (0.079)	-0.319 (0.107)	-0.006 (0.003)	3.826 (0.693)
Slovak Republic	-0.103 (0.110)	-0.687 (0.949)	-0.923 (2.166)	0.018 (0.024)	0.323 (0.644)	0.718 (1.163)	-8.384 (9.168)	0.793 (3.073)	3.905 (2.284)
MG Estimates	NA	-0.150 (0.165)	-1.033 (0.511)	0.008 (0.006)	-0.120 (0.161)	0.411 (0.211)	-2.633 (1.490)	1.007 (0.612)	NA
median	NA	-0.111	-0.923	0.005	-0.158	0.621	-1.362	0.793	NA
MG* Estimates	NA	-0.016 (0.124)	-1.061 (0.658)	0.006 (0.007)	-0.231 (0.151)	0.335 (0.254)	-1.195 (0.507)	1.060 (0.787)	NA

MG* Estimates are obtained when the Slovak Republic is excluded from the pool of countries. Standard errors are in parentheses.

Table 4: Residual Diagnostics - the MG Estimates

	Autocorrelation	Normality	Heteroscedasticity	R^2 adj.
Czech Republic	1.42	0.68	0.03	0.52
Hungary	0.83	0.38	0.21	0.14
Poland	0.13	0.08	3.72	0.40
Slovenia	0.85	1.70	0.39	0.54
Slovak Republic	1.77	1.61	0.08	0.19

The 5 % critical value for chi^2(1) and chi^2(2) are 3.84 and 5.99, respectively.

Table 5: the PMG Estimates

Group	**EU 5**		**EU 4**	
Variable	Coefficient	Std. Error	Coefficient	Std. Error
ca	-0.113	0.053	-0.136	0.067
fdi	-0.685	0.688	-1.225	1.149
dlr	-0.001	0.006	-0.004	0.007
nfa	0.064	0.121	-0.015	0.201
ope	-0.012	0.123	-0.010	0.176
dpro	-2.561	0.585	-2.745	0.791
tot	1.967	0.727	1.859	0.800

Table 6: Residual Diagnostics and the ϕ estimates using PMGE

	Autocorrelation	Normality	Heteroscedasticity	R^2 adj.	Phi
Czech Republic	1.45	7.43	4.01	-0.20	0.000 (0.002)
Hungary	2.80	1.26	1.37	0.06	-0.246 (0.086)
Poland	0.20	0.38	3.42	0.28	-0.168 (0.054)
Slovenia	3.13	24.79	4.80	-0.21	0.000 (0.001)
Slovak Republic	0.03	1.89	0.06	0.04	-0.102 (0.069)

The 5 % critical value for chi^2(1) and chi^2(2) are 3.84 and 5.99, respectively. The individual constants are not reported for brevity.

Table 7: Projections Orthogonal to the Z_t Vector

	rer	fdi	nfa	open	dpro	tot
dlr	0.070 (0.036)	-0.003 (0.002)	0.009 (0.021)	-0.020 (0.030)	0.001 (0.002)	-0.099 (0.061)
ca	0.459 (0.182)	-0.014 (0.016)	-0.337 (0.144)	-0.151 (0.081)	-0.254 (0.127)	-2.265 (2.113)

The standard errors are in parentheses.

Table 8: Estimation of Equation (11)

	Coefficient	Std. Error
$M_Z fdi_t$	-5.866	2.726
$M_Z nfa_t$	-0.268	0.505
$M_Z open_t$	-1.241	1.158
$M_Z dpro_t$	1.457	0.197
$M_Z tot_t$	-0.202	0.080

The dependent variable is $M_Z rer_t$.

Table 9: Estimation of Equation (16)

Variable	Coefficient	St. Error
trend	-5.2875	0.4217
trend^2	0.0827	0.0072

The Estimation method is iterated GLS. The coefficients are multiplied by 100.

Table 10: Estimation of the Optimal Timing (in Years)

Variable	Estimate	90 % confidence interval
t^*	7.99	7.35 – 9.26
Optimal timing	2003Q1	2002Q3 - 2003Q3

The beginning period is 1995Q1.

Figures

Figure 1: Exchange Rate Dynamics in the EU 5 Countries (percentage growth)

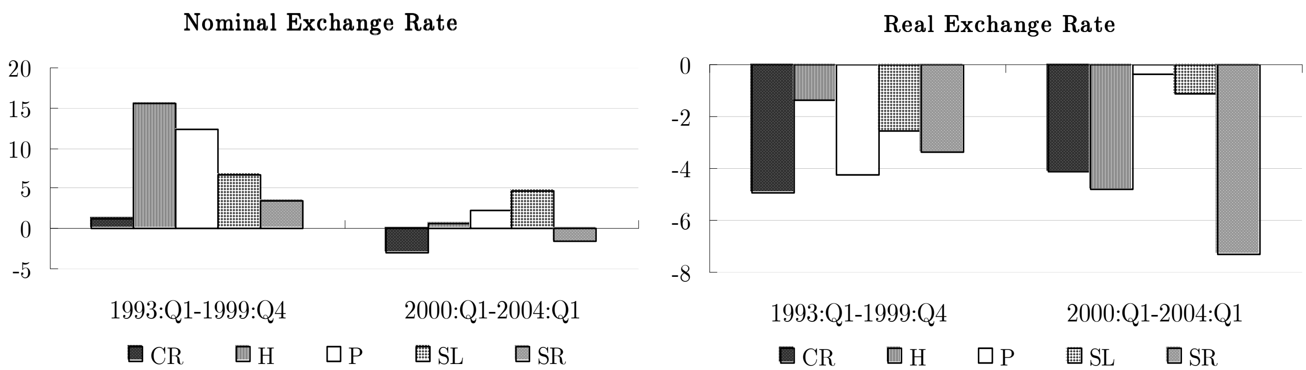

Figure 2: Inflation Rates and Price Levels in the EU 5 Countries

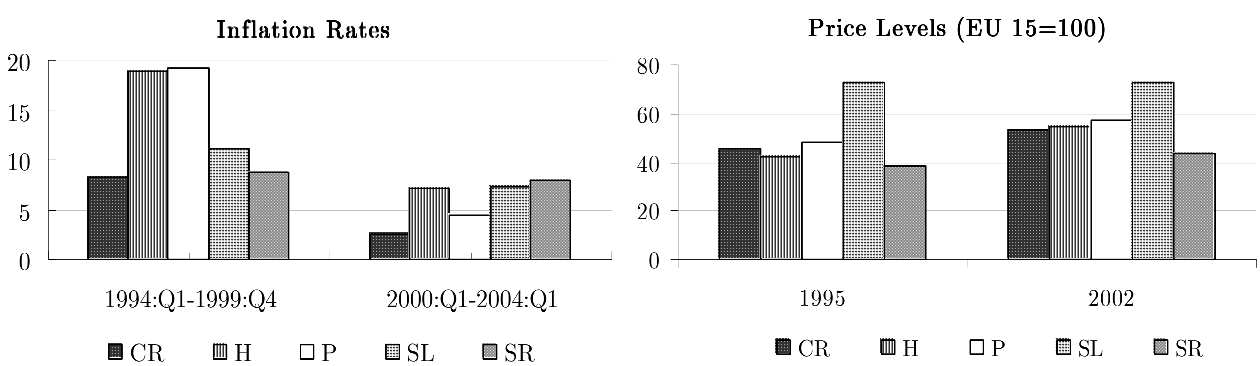

Figure 3: Average Real GDP Growth and Real GDP per Capita in EU 5

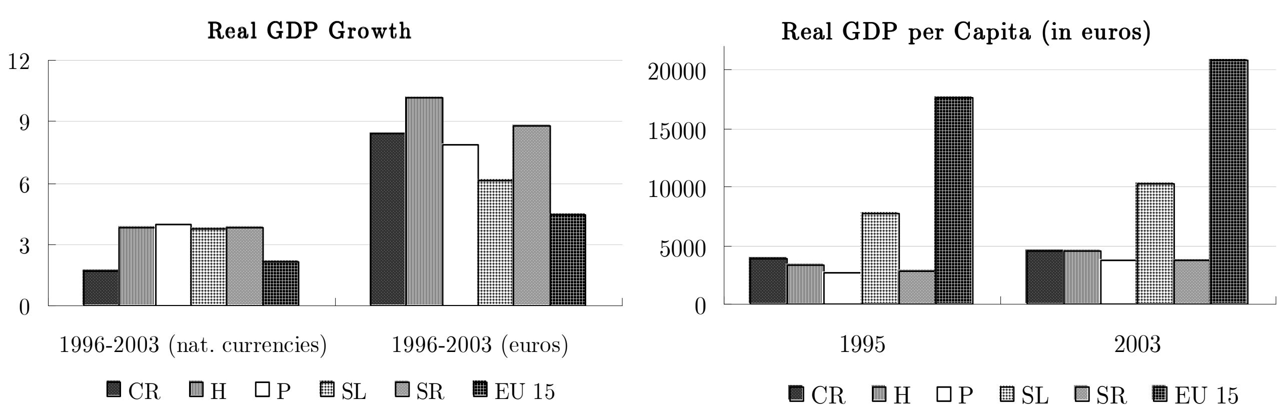

Figure 4: Kernel Estimates of the Coefficient Estimates on the RER Determinants

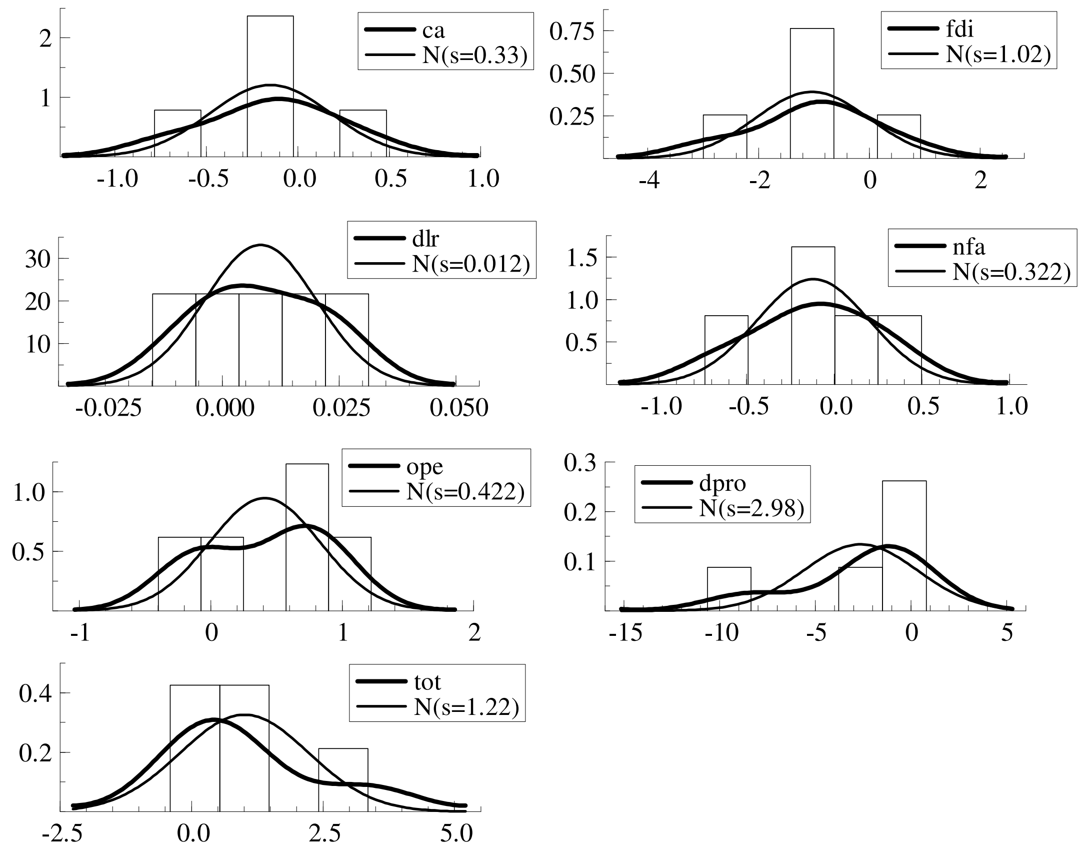

Figure 4: Kernel Estimates of the Coefficient Estimates on the RER Determinants