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NOMINAL AND REAL EXCHANGE RATE CO-MOVEMENTS

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This paper investigates the existence of common movements between nominal and real exchange rates across different countries in three regions – North America, Western Europe, and Central and Eastern Europe – by using the multi-factor model. It also examines the role of macroeconomic fundamentals (i.e., prices, money and output) in order to explain the variance of the exchange rate global factor. The findings suggest the existence of co-movements among exchange rates. The exchange rate global factor seems to play a central role in explaining exchange rate variability in Western Europe, whereas regional and country-specific factors are the most important ones in North America and Central and Eastern Europe, respectively. Finally, the paper shows empirical evidence in favour of the connection between exchange rate global factor variability and macroeconomic fundamentals. Moreover, the importance of fundamentals has increased in the recent global crisis.

JEL classification codes: E32, F44, F31
Key words: exchange rates; co-movements; CEE countries; dynamic factor

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I. Introduction

The literature on exchange rates has presented two main empirical regularities in recent decades. On the one hand, real exchange rates co-move closely with nominal exchange rates at short and medium horizons (see, for example, Burstein and Gopinath 2013), which implies that nominal shocks to the economy may have real effects. This first regularity, from a theoretical point of view, is commonly interpreted as an indication of price stickiness and would support the exchange rates models with sluggish price adjustment, such as the sticky-price monetary model (Dornbusch 1976). On the other hand, the relationship between exchange rates and other macroeconomic variables (underlying fundamentals) is weak. Thus, Meese and Rogoff (1983) show that the simple random walk model performs no worse than economic models in forecasting exchange rates at short to medium horizons. Baxter and Stockman (1989) show that flexible exchange rate regimes lead to sharp increases in nominal and real exchange rate volatility, although it has little effect on the distribution of fundamental macroeconomic aggregates. Flood and Rose (1995) come to similar conclusions. Obstfeld and Rogoff (2000) refer to the weak linkage between exchange rates and underlying fundamentals as the exchange rate disconnect puzzle.

The contribution of this paper is to extend the empirical work on these two regularities by using a different approach based on multi-factor analysis. We first examine the existence of co-movements between nominal and real exchange rates across North American countries (the United States and Canada), European Union countries (Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom) and Central and Eastern European countries (the Czech Republic, Hungary, Poland, Slovenia and Slovakia). Although the analysis of co-movements among macroeconomic variables has substantially grown in recent decades, there is no study that examines co-movements among nominal and real exchange rates across countries (see Section II). For this purpose, we use the multi-factor model, in the spirit of Kose, Otrok and Whiteman (2003, 2008) and Kose, Otrok and Prasad (2012). Moreover, we use effective exchange rate data because, from a macroeconomic point of view, the analysis of the effective exchange rates seems to be more appropriate than that of the simple market exchange rates. This is especially true for countries whose trade is diversified given that it considers the behaviour of the exchange rate of a country in relation to all its trading partners and allows one to assess the comparative changes in the country's real economic circumstances. Secondly, we examine the forces behind the exchange rate global factor, analysing which part of its variance is explained by macroeconomic fundamentals (*i.e.*, prices, money and output). In doing so, we follow the approach developed by Crucini, Kose and Otrok (2011).

The rest of the paper is structured as follows. Section II presents a literature review on co-movements. Section III describes the data and methodology. Section IV reports our empirical findings, and Section V draws some concluding remarks.

II. Literature review on co-movements

The analysis of co-movements among macroeconomic variables has developed in several strands. The first strand in the literature has shown the existence of an international business cycle (see, for instance, Backus and Kehoe 1992; Gregory, Head, and Raynauld 1997; Kose, Otrok, and Whiteman 2003; among others).

The second strand of studies has focused on the existence of a European business cycle, although no consensus has emerged.[1] Recently, there has also been a growing interest in research into the existence of a common business cycle between the European Union (EU) countries and the Central and Eastern European (CEE) countries. Boone and Maurel (1998) find that business cycles in CEE countries are similar to those in Germany and the Euro Zone, suggesting that full European Monetary Union (EMU) membership for CEE countries would be fruitful. In a survey paper, Fidrmuc and Korhonen (2006) report 35 studies on business cycle correlation between the CEE countries and the EU countries. Their meta-analysis confirms that business cycles in several CEE countries are highly correlated with the Euro Zone business cycle. Moreover, their results indicate that many new EU member states (*e.g.*, Hungary, Poland and Slovenia) have achieved a relatively high degree of business cycle correlation with the Euro Zone. Artis, Fidrmuc and Scharler (2008) analyze potential sources of business cycle synchronization for a set of OECD and CEE countries, and they find evidence that supports the endogeneity hypothesis of the optimal currency area criteria.

[1] See, for example, Artis, Krolzig and Toro (2004) and the references therein for evidence in favour of a European business cycle. However, authors like Kose, Otrok and Whiteman (2003) and Camacho, Pérez-Quirós and Saiz (2008) do not support such result.

In this line, Jiménez-Rodríguez, Morales-Zumaquero and Égert (2013) show evidence in favour of the business cycle synchronization between eight EMU countries (Austria, Belgium, Finland, France, Germany, Italy, the Netherlands and Spain) and five CEE countries (the Czech Republic, Hungary, Poland, Slovakia and Slovenia). Their results show a high degree of concordance between country-specific and European business cycles.

The previous two strands in the literature have been basically focused on the behaviour of output, consumption and investment. A third strand in the literature has paid attention to the nominal/real convergence between the CEE countries and the EU countries. Thus, Brada and Kutan (2001) examine monetary policy convergence between the candidate economies and the EU, proxied by Germany, and find no convergence between base money in Germany and the transition-economy candidates for EU membership. Kutan and Yigit (2005) show strong evidence of real stochastic convergence (output convergence) to EU standards for all CEE economies, which are now new EU members, although the degree of nominal convergence (monetary policy and prices convergence) is idiosyncratic.

Finally, a more recent strand in the literature has examined co-movements between bilateral exchange rates.[2] Black and McMillan (2004), among others, using a series of daily dollar exchange rates, report evidence in favor of a convergence within the European countries. Orlov (2009) analyzes whether the 1997 Asian crisis caused a contagion in foreign exchange markets. However, there is no study that examines co-movements among nominal and real exchange rates across countries. This issue is very relevant for several reasons. Firstly, many observers argue that stable long-run real exchange rates are important for real convergence of the CEE countries to the rest of the EU countries and thus for successful integration. Secondly, the final goal of the CEE countries is a smooth adoption of the euro by inducing higher stability in the exchange rates against the euro (see Horobet, Ilie and Joldes, 2009). Finally, the existence of co-movements in real exchange rates could reveal a strong commitment by central banks in

[2] There are also some studies that have investigated co-movements between exchange rates and macroeconomic variables (see, e.g., Duarte, Restuccia and Waddle 2007; Reboredo 2012; among others). Duarte, Restuccia and Waddle (2007) study the cyclical co-movement between exchange rates and real aggregates in a data set of 36 countries. Reboredo (2012) examines oil prices and currency market co-movements.

these countries: real exchange rates convergence will require the convergence of monetary policy.

III. Data and methodology

A. Data

We use quarterly data on the nominal effective exchange rate (NEER) and real effective exchange rates (based on both the consumer price index, REER-CPI, and unit labour costs, REER-ULC) from three sets of representative countries:[3] the North American countries, NAC-2, (the United States and Canada), the European Union countries, EUC-11 (Austria, Belgium, Denmark, Finland, France, Germany, Italy, the Netherlands, Spain, Sweden and the United Kingdom), and the Central and Eastern European countries, CEEC-5 (the Czech Republic, Hungary, Poland, Slovenia and Slovakia). The effective exchange rate data come from the Eurostat database. The common period runs from 1994:2 to 2010:4 due to the data availability for the CEEC-5. Consequently, we use three series per country for the 18 countries, with 67 time series observations. Three regions, NAC-2, EUC-11 and CEEC-5, are considered. In the analysis of the common movements and the estimations of the global, regional and country-specific factors, each series was log first-differenced and demeaned.

In addition, the role of macroeconomic fundamentals is examined using quarterly data on monetary aggregate (M3 for all countries except Germany – M1 – and Slovakia – M2) from the OECD (Organisation for Economic Co-operation and Development) and Datastream databases (common sample: 1996:1 to 2010:4). We consider quarterly data for real output, consumption and investment (common sample: 1997:1-2010:4) for the output variables. Finally, we employ quarterly data on consumer prices (all items, food, and non-energy and non-food) for the price variables (common sample: 1996:1-2010:4). The data for the output and price variables come from the OECD database. In order to obtain the global factors for each macroeconomic fundamental, data were first-differenced and demeaned.

[3] We have selected the most representative countries within each region. It is worth noting that, according to data from the Bank for International Settlements, the countries considered have relevant trade relationships and this is one of the main reasons to choose these countries (see Table A1 in online appendix). The geographic proximity of the EUC-11 and the CEEC-5 is also considered.

B. The multi-factor model

This sub-section closely follows the description offered by Kose, Otrok and Whiteman (2008) on the multi-factor model proposed by Kose, Otrok and Whiteman (2003), which we use for the estimation of the dynamic factors.

We consider that there are K dynamic unobserved factors to characterize the temporal co-movements in the exchange rate time series. Let N denote the number of countries, M the number of time series per country,[4] R the number of regions, and T the length of the time series. Observable variables are denoted by y_{it} for $i=1,..,M\times N$, $t=1,...,T$. There are three types of factors: N country-specific factors ($f_n^{country}$, one per country), R regional factors (f_r^{region} , in this case, three regional factors: NAC-2, EUC-11 and CEEC-5), and the single global factor (f^{global}). Thus, the i^{th} observable variable at time t ($y_{i,t}$) evolves as:

$$y_{i,t} = a_i + b_i^{global} f_t^{global} + b_i^{region} f_{r,t}^{region} + b_i^{country} f_{n,t}^{country} + \varepsilon_{i,t},$$
$$E\left[\varepsilon_{i,t}\varepsilon_{j,t-s}\right] = 0 \quad \text{for } i \neq j, \tag{1}$$

where r denotes the region number and n the country number. The coefficients b_i^j are the factor loadings,[5] and reflect the degree to which the variation in $y_{i,t}$ can be explained by each factor.[6] The unexplained idiosyncratic errors $\varepsilon_{i,t}$ are assumed to be normally distributed, but may be serially correlated. They follow p_i-order autoregressions:

$$\varepsilon_{i,t} = \phi_{i,1}\varepsilon_{i,t-1} + \phi_{i,2}\varepsilon_{i,t-2} + \ldots + \phi_{i,p_i}\varepsilon_{i,t-p_i} + u_{i,t},$$
$$E\left[u_{i,t}u_{j,t-\tau}\right] = \begin{cases} \sigma_i^2 & for\ i = j, \tau = 0, \\ 0 & otherwise. \end{cases} \tag{2}$$

[4] Three series (REER-CPI, REER-ULC and NEER) per country are considered for the analysis of the exchange rate global factor.
[5] In order to identify signs, one of the factor loadings must be positive for each of the factors. In particular, factor loading for the global factor needs to be positive for the US REER-CPI; country factors are identified by positive factor loadings for REER-CPI for each country, and the regional factors are identified by positive loadings for the REER-CPI of the first country listed in each region (i.e., the US, Germany and the Czech Republic).
[6] Notice that there are $M\times N$ time series to be "explained" by the $N+R+1$ factors.

The evolution of the factors is likewise governed by an autoregression of order q_k with normal errors:

$$f_{k,t} = \varepsilon_{f_k,t}, \tag{3}$$

$$\varepsilon_{f_k,t} = \phi_{f_k,1}\varepsilon_{f_k,t-1} + \phi_{f_k,2}\varepsilon_{f_k,t-2} + \ldots + \phi_{f_k,q_k}\varepsilon_{f_k,t-q_k} + u_{f_k,t} \ ,$$

$$E\left[u_{f_k,t}u_{f_k,t}\right] = \sigma^2_{f_k}; E\left[u_{f_k,t}u_{i,t-\tau}\right] = 0, \text{ for all } k,\ i \text{ and } \tau\ . \tag{4}$$

Notice that all the innovations, $u_{i,t}$, $i=0,\ldots,M\times N$ and $u_{f_k,t}$, $k=1,\ldots,K$, are assumed to be zero mean, contemporaneously uncorrelated normal random variables.[7]

The estimates follow the Otrok and Whiteman (1998) method.[8]

C. Variance analysis of the exchange rate global factor

The above-mentioned multi-factor model is also applied to money, output and price variables (first-differenced and demeaned) in order to obtain the global factor for each group of these variables.[9] We then regress the global factor of the effective exchange rate on the global factors in each group of variables:

$$f^{global}_{EER,t} = \beta_M f^{global}_{M,t} + \beta_Y f^{global}_{Y,t} + \beta_P f^{global}_{P,t} + \zeta_t\,. \tag{5}$$

By applying the variance operator to the both sides of the equation (5), the variance of the estimated exchange rate global factor can be decomposed into parts based on the global factors in each group of variables considered (money, output and price variables) plus an idiosyncratic component.[10]

[7] It is assumed that each $\sigma^2_{f_k}$ is equal to a constant.

[8] The length of both the idiosyncratic and factor autoregressive polynomials is 3.

[9] Notice that the country-specific factor is not considered in the case of monetary aggregates because the idiosyncratic component captures it when only one variable is considered.

[10] As Crucini, Kose and Otrok (2011) indicate, we have to orthogonalize the factors of the variables considered in order to ensure that the variance sums to one hundred. The order of orthogonalization used is price, output and money variables.

IV. Empirical results

This section reports the empirical results. The first subsection presents the time pattern in the exchange rate global factor and its relationship with the effective exchange rate series of the regions considered. The second subsection discusses the results of the variance decomposition, which measures the contribution of the global, regional and country-specific factors to variations in the exchange rate series in each country. Finally, the third subsection shows the decomposition of the variance of the estimated exchange rate global factor, which allows one to better establish the forces behind it.

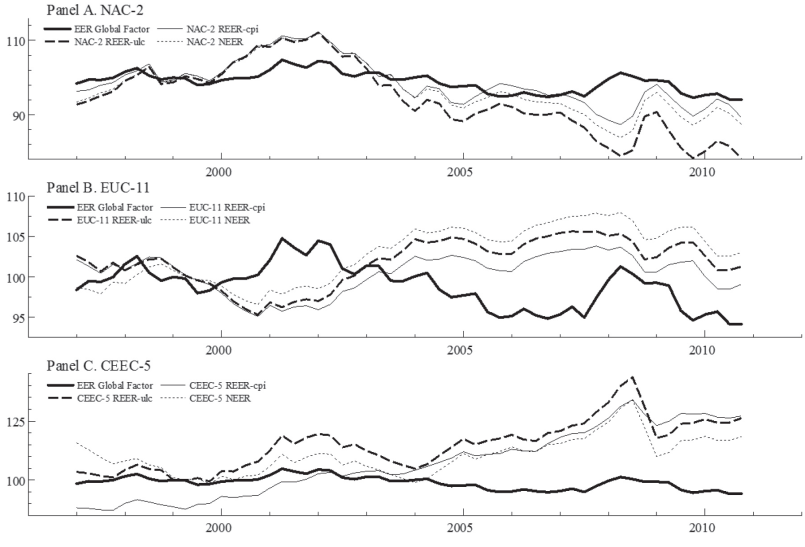
A. The exchange rate global factor

Figure 1 displays the level of the exchange rate global factor and the level of the effective exchange rate variables for the NAC-2, EUC-11 and CEEC-5.[11] Panel A of Figure 1 suggests that, in general, the exchange rate global factor seems to properly capture the evolution of the NAC-2 REER-CPI. In particular, we observe that both the global factor and the NAC-2 REER increase until 2002, which means that there is a real appreciation in domestic currency and, consequently, a loss of competitiveness. However, these two series decrease from 2002 until now, indicating a real depreciation in domestic currency and therefore a gain in competitiveness. Panel B of Figure 1 shows that both the exchange rate global factor and the EUC-11 REER-CPI move together along the entire considered period (except from 2000 to 2004 when they move in opposite directions). Finally, Panel C of Figure 1 illustrates that both the global factor and the CEEC-5 REER-CPI appear to move close to one another across the sample (overall at the beginning) with the global factor series being smoother.[12] In addition, these same results are found when we use the REER-ULC and NEER series (see Panels A–C of Figure 1).

[11] For the construction of the regional series, we use a weighted average of the series of each country belonging to the same region by using weights based on GDP per capita – PPP.

[12] We split the sample into two different subsamples considering the introduction of the euro as the break date (since it was the date when the euro became a real currency and a single monetary policy was introduced under the authority of the European Central Bank). As expected, the evolution of the exchange rate global factor in the second subsample is practically identical to the one found in the full sample (available from the authors upon request).

Figure 1. Exchange rate global factor and REER-CPI, REER-ULC and NEER variables



Note: This figure plots the effective exchange rate global factor, REER-CPI, REER-ULC, and the NEER (all in levels) for NAC-2 (Panel A), EUC-11 (Panel B), and CEEC-5 (Panel C).

Panels A–C of Figure 2 plot the exchange rate global factor together with the money, price and output global factors (in growth rate terms), respectively. The three global factors of fundamental variables are smoother than the exchange rate global factor. Moreover, it seems that the output global factor exhibits a similar behaviour to the exchange rate global factor in several periods, overall at the end of the sample.

B. Variance analysis

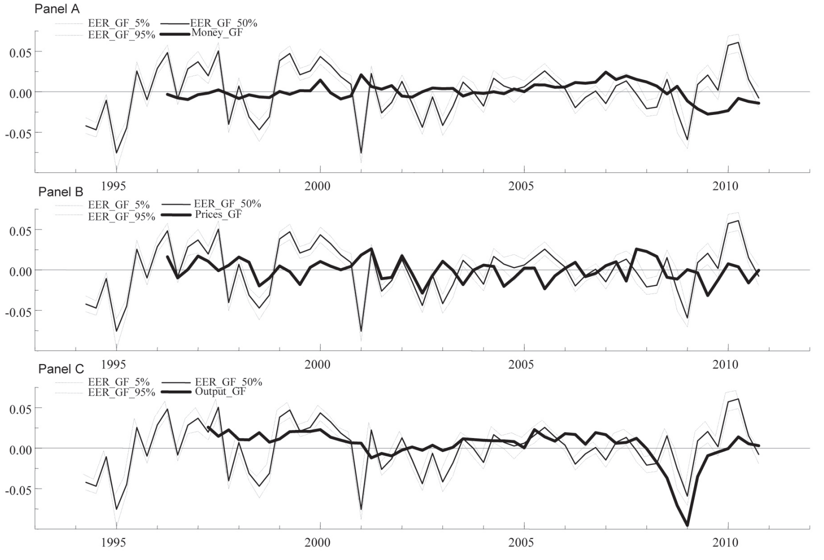
Exchange rate series

In this sub-section we decompose the variance of the exchange rate series for each country considered into the fraction that is due to the global, regional and country-specific factors and the idiosyncratic component. Panels A–C of Table 1 show the variance decomposition for the exchange rate series for the NAC-2, the EUC-

11 and the CEEC-5, respectively. This Table reports the median of the posterior quantiles, as well as the 33% and the 66% quantiles.

Looking at the 50% quantiles, the global factor does not seem to contribute significantly to the variance of the exchange rate series for the US and Canada. However, the regional factor plays an important role in explaining the exchange rate variability (specifically explaining around 70% in the US and around 55% in Canada). The country-specific factor also seems to be very relevant in explaining the variations in the exchange rates in Canada. Finally, the idiosyncratic factor plays a negligible role in the NAC-2.

Figure 2. Exchange rate global factor and global factors of macroeconomic fundamentals



Note: Panels A–C display the growth rate of the exchange rate global factor (along with 5 and 95 percent quantile bands) and the growth rate of the money, price and output global factors, respectively.

Table 1. Variance analysis: exchange rates

Country(*)		REER -CPI			REER -ULC			NEER		
		Panel A: NAC-2								
		33	50	66	33	50	66	33	50	66
US	global	0.031	0.051	0.075	0.031	0.050	0.076	0.020	0.036	0.058
	country	0.098	0.196	0.270	0.088	0.177	0.247	0.086	0.184	0.254
	region	0.599	0.701	0.840	0.625	0.729	0.859	0.639	0.739	0.871
	idiosyn	0.027	0.029	0.032	0.018	0.020	0.022	0.017	0.019	0.021
CAN	global	0.084	0.108	0.139	0.073	0.097	0.127	0.076	0.099	0.130
	country	0.273	0.333	0.380	0.272	0.330	0.379	0.269	0.326	0.375
	region	0.455	0.544	0.632	0.465	0.557	0.645	0.468	0.561	0.647
	idiosyn	0.016	0.017	0.019	0.014	0.015	0.017	0.013	0.014	0.016
		Panel B: EUC-11								
		33	50	66	33	50	66	33	50	66
GER	global	0.728	0.766	0.801	0.790	0.826	0.858	0.810	0.845	0.876
	country	0.002	0.006	0.016	0.001	0.002	0.004	0.001	0.001	0.002
	region	0.080	0.111	0.149	0.070	0.101	0.135	0.074	0.103	0.137
	idiosyn	0.093	0.104	0.113	0.063	0.067	0.071	0.043	0.047	0.051
UK	global	0.216	0.234	0.247	0.195	0.215	0.229	0.198	0.218	0.231
	country	0.709	0.717	0.726	0.732	0.740	0.749	0.731	0.740	0.747
	region	0.005	0.014	0.033	0.006	0.016	0.036	0.006	0.015	0.035
	idiosyn	0.025	0.027	0.029	0.019	0.021	0.023	0.018	0.020	0.022
FRA	global	0.601	0.650	0.695	0.577	0.628	0.673	0.678	0.723	0.764
	country	0.036	0.044	0.053	0.033	0.042	0.051	0.027	0.034	0.041
	region	0.173	0.216	0.268	0.196	0.240	0.294	0.129	0.167	0.213
	idiosyn	0.078	0.086	0.093	0.078	0.086	0.093	0.066	0.072	0.079
ITA	global	0.013	0.023	0.031	0.007	0.014	0.020	0.011	0.018	0.025
	country	0.802	0.821	0.837	0.803	0.820	0.835	0.846	0.859	0.871
	region	0.059	0.079	0.105	0.060	0.078	0.102	0.042	0.056	0.076
	idiosyn	0.065	0.073	0.081	0.076	0.083	0.090	0.056	0.062	0.069
SPA	global	0.266	0.316	0.351	0.316	0.363	0.399	0.432	0.486	0.524
	country	0.227	0.251	0.274	0.178	0.198	0.218	0.140	0.155	0.171
	region	0.195	0.238	0.305	0.209	0.246	0.316	0.152	0.189	0.262
	idiosyn	0.168	0.187	0.209	0.166	0.181	0.199	0.147	0.159	0.173
SWE	global	0.023	0.033	0.045	0.051	0.064	0.079	0.038	0.050	0.064
	country	0.635	0.660	0.684	0.653	0.674	0.695	0.646	0.671	0.693
	region	0.236	0.263	0.290	0.188	0.214	0.242	0.216	0.244	0.273
	idiosyn	0.034	0.037	0.041	0.037	0.040	0.044	0.027	0.030	0.033
FIN	global	0.532	0.562	0.586	0.564	0.590	0.612	0.545	0.569	0.591
	country	0.274	0.284	0.293	0.272	0.281	0.291	0.285	0.294	0.304
	region	0.057	0.080	0.111	0.041	0.061	0.088	0.047	0.069	0.090
	idiosyn	0.064	0.069	0.076	0.058	0.063	0.069	0.059	0.065	0.072
DEN	global	0.795	0.832	0.856	0.725	0.761	0.784	0.821	0.854	0.880
	country	0.008	0.014	0.021	0.018	0.032	0.047	0.008	0.013	0.019
	region	0.036	0.059	0.095	0.042	0.065	0.102	0.038	0.061	0.095
	idiosyn	0.085	0.091	0.097	0.128	0.139	0.150	0.063	0.068	0.073
NET	global	0.711	0.741	0.761	0.795	0.825	0.846	0.814	0.853	0.886
	country	0.008	0.016	0.027	0.002	0.005	0.010	0.000	0.001	0.001
	region	0.030	0.048	0.078	0.034	0.055	0.085	0.076	0.107	0.145
	idiosyn	0.181	0.190	0.199	0.105	0.111	0.116	0.034	0.037	0.040
BEL	global	0.634	0.686	0.719	0.740	0.785	0.819	0.789	0.830	0.865
	country	0.003	0.007	0.014	0.001	0.003	0.006	0.000	0.001	0.002
	region	0.123	0.157	0.208	0.088	0.121	0.165	0.092	0.126	0.165
	idiosyn	0.137	0.145	0.153	0.082	0.086	0.091	0.038	0.041	0.044
AUS	global	0.737	0.771	0.803	0.738	0.774	0.805	0.822	0.851	0.871
	country	0.001	0.002	0.004	0.001	0.002	0.005	0.001	0.002	0.003
	region	0.071	0.101	0.138	0.083	0.113	0.149	0.040	0.062	0.089
	idiosyn	0.115	0.121	0.126	0.101	0.106	0.111	0.078	0.082	0.087

Table 1. (Continued) Variance analysis: exchange rates

Country		REER-CPI 33	REER-CPI 50	REER-CPI 66	REER-ULC 33	REER-ULC 50	REER-ULC 66	NEER 33	NEER 50	NEER 66
		Panel C: CEEC-5								
CZE	global	0.011	0.014	0.017	0.001	0.001	0.002	0.007	0.011	0.014
	country	0.785	0.814	0.843	0.824	0.856	0.887	0.787	0.823	0.862
	region	0.036	0.063	0.093	0.030	0.061	0.094	0.054	0.086	0.124
	idiosyn	0.096	0.104	0.114	0.070	0.077	0.086	0.066	0.072	0.079
HUN	global	0.053	0.060	0.066	0.074	0.081	0.089	0.068	0.076	0.088
	country	0.759	0.777	0.795	0.757	0.777	0.795	0.778	0.796	0.814
	region	0.007	0.016	0.031	0.005	0.014	0.025	0.004	0.009	0.017
	idiosyn	0.127	0.138	0.149	0.110	0.121	0.133	0.099	0.110	0.122
POL	global	0.084	0.090	0.097	0.076	0.083	0.090	0.109	0.120	0.132
	country	0.812	0.824	0.833	0.817	0.829	0.840	0.740	0.756	0.770
	region	0.003	0.011	0.023	0.006	0.016	0.031	0.011	0.025	0.045
	idiosyn	0.063	0.069	0.076	0.057	0.065	0.074	0.081	0.090	0.101
SLV	global	0.365	0.374	0.384	0.409	0.419	0.428	0.325	0.335	0.344
	country	0.301	0.331	0.357	0.337	0.368	0.397	0.264	0.299	0.330
	region	0.011	0.021	0.037	0.003	0.009	0.024	0.036	0.052	0.083
	idiosyn	0.240	0.263	0.289	0.169	0.190	0.214	0.274	0.302	0.333
SLK	global	0.006	0.008	0.009	0.006	0.007	0.009	0.001	0.001	0.002
	country	0.687	0.702	0.716	0.820	0.832	0.845	0.843	0.856	0.868
	region	0.031	0.037	0.043	0.040	0.048	0.055	0.030	0.036	0.042
	idiosyn	0.241	0.254	0.266	0.099	0.111	0.123	0.096	0.106	0.116

Notes: This table presents the variance decomposition of exchange rates series for the NAC-2 (Panel A), the EUC-11 (Panel B) and the CEEC-5 (Panel C). We report the median of posterior quantiles, as well as 33% and 66% quantiles. REER-CPI: real effective exchange rate based on consumer price index; REER-ULC: real effective exchange rate based on unit labour cost, NEER: nominal effective exchange rate. (*) US: The United States; CAN: Canada; AUS: Austria; BEL: Belgium; DEN: Denmark; FIN: Finland; FRA: France; GER: Germany; ITA: Italy; NET: The Netherlands; SPA: Spain; SWE: Sweden; UK: The United Kingdom; CZE: The Czech Republic; HUN: Hungary; POL: Poland; SLV: Slovenia; and SLK: Slovakia.

The results for the EUC-11 suggest that the global factor plays a central role in explaining the fluctuations in the exchange rate series in all countries except for Italy, Sweden and the United Kingdom. The importance of the global factor could be easily justified by the existence of a common currency and the lack of independent monetary policy.[13] The results for Sweden and the United Kingdom, non-euro countries, indicate that there is a substantial importance in the country-specific factor (specifically around 65% and 70%, respectively). For Italy, the

[13] It is worth noting that the main trading partner of all countries considered is basically the Euro Zone (see Table A1 in online appendix), which may indicate that the global factor could be driven by what happens in the Euro Zone since it is the region with the highest trade. The value of the sum of imports and exports of goods in the EUC-11 was 360.96 billions of US dollars during the period 1994-2010, whereas this value was 149.05 and 130.09 billions of US dollars in the NAC-2 and the CEEC-5, respectively (see Table A2 in online appendix).

country-specific factor accounts for 80%, most likely due to the peculiar behaviour of the lira in the European Monetary System (EMS), especially during the successive crises throughout September 1992–January 1999.[14] Finally, the results show a strong importance in the global factor for Denmark, a non-euro country, probably due to the fact that this country entered the ERMII in 1999, when the euro was created, and it continues to be a member.

The variance decomposition for the exchange rate series indicates a substantial importance in the country-specific factor in all the CEEC-5 countries, accounting for, on average, around 70% of variability. This is a reasonable result due to the variety of exchange rate regimes followed by these economies and can be explained by both their structural diversity and their need to control exchange rates and inflation. Finally, the results for Slovenia — a member of the Euro Zone since 2007 — indicate that the global factor plays a role, explaining around 30% of the fluctuations in the exchange rates.

When we consider the subsample after the euro (1999:1-2010:4), the global factor increases its importance with respect to the full sample in the US and in all the Euro Zone countries. In particular, we observe that Italy now behaves like the rest of the Euro Zone countries with the global factor having a considerable role. This result seems to be reasonable since the long period of instability of the lira previous to 1999 has been eliminated from the sample. Moreover, the global factor shows a slightly higher importance in Denmark, which again reveals that the evolution of the Danish krone is really closely tied to the evolution of the euro. However, no significant changes are found in the UK and Sweden. The global factor increases its importance in Slovenia (now explaining around 53%), but not in the remaining CEEC-5 countries.[15]

In short, the existence of a global factor that properly captures the evolution of both nominal and real exchange rates (see subsection IV.A), as well as the fact that the variance of real and nominal exchange rates is explained by the same factors as illustrated in Table 1, show evidence in favour of co-movements among nominal

[14] On October 16, 1992 the Italian lira exited from the ERM of the EMS. The re-entry of the lira into the ERM-EMS was on November 25, 1996. See, for instance, Ledesma, Navarro, Pérez and Sosvilla (2008).
[15] All this information is available in the online appendix. Slovakia entered the Euro Zone in 2009 and our sample ends in 2010, which could explain the low importance of the global factor in this country.

and real exchange rates not only in developed countries but also in transition economies. This evidence is in line with previous empirical literature supporting the exchange rates theoretical models with sluggish price adjustment.

Exchange rate global factor

In this sub-section, we present the results relative to the variance of the estimated exchange rate global factor decomposed into parts based on the global factors in each group of variables considered (money, output and price variables) plus an idiosyncratic. Table 2 contains these results and reveals that output is the most important fundamental variable for explaining the variability of the exchange rate global factor. Specifically, this fundamental variable explains about 15% of the fluctuation in the exchange rate global factor in the full common sample (1997:2-2010:4), about 35% for subsamples that start in the mid-2000s and for the last part of the sample (2008:1-2010:4). Money accounts for less than 5% over the full sample, less than 9% for the shorter sample starting in the mid-2000s and less than 18% for the sample focused on the last global crisis. However, price variables only explain less than 5% for any sample considered.

Table 2. Variance analysis: exchange rate global factor

Sample period	Prices (%)	Money (%)	Output (%)
1997:2-2010:4	0.01	4.00	14.52
2000:1-2010:4	0.41	8.22	22.94
2002:1-2010:4	1.23	5.86	26.81
2004:1-2010:4	5.52	4.47	35.66
2006:1-2010:4	3.44	8.85	36.72
2008:1-2010:4	2.14	17.5	36.37

Note: This table presents the percentage of the exchange rate global factor variability explained by the macroeconomic fundamentals (prices, money and output) for different sample periods.

According to these results, the movements of output have been the most important variable from those considered here (followed by money and prices) for explaining the evolution of the co-movements in the exchange rates. Notice that all the fundamental variables considered in the full common sample explain about 19%, which means that 81% of the variance is explained by other factors not considered here. Notwithstanding this, it is observed that the situation changes when the sample is reduced to include just the last global crisis, with the output variable explaining double that found in the full common sample (about 35%) and all the considered fundamental variables explaining about 55%. It is worth noting that these latter findings differ from the previous empirical literature where the relationship between exchange rates and macroeconomic variables is weakly supported by the data (see, for example, Meese and Rogoff 1983; Baxter and Stockman 1989; Flood and Rose 1995; Obstfeld and Rogoff 2000; Cheung et al. 2005; Sarno 2005). Thus, these results may help to clarify the exchange rate disconnect puzzle.

V. Concluding remarks

In this paper we have investigated the existence of common movements between nominal and real exchange rates across different countries in three regions by using the multi-factor model. In addition, we have studied the role of macroeconomic fundamentals (i.e., prices, money and output) in order to explain the variance of the exchange rate global factor.

The existence of a global factor that properly captures the evolution of both nominal and real exchange rates, as well as the fact that the variance of real and nominal exchange rates is explained by the same factors, show evidence in favour of co-movements among nominal and real exchange rates not only in developed countries but also in transition economies. This evidence would support the exchange rates models with sluggish price adjustment.

Additionally, we observe that the variance of the effective exchange rates is explained by a different factor depending on the region. In particular, the regional factor seems to play the central role in the NAC-2. Thus, exchange rates in these countries are mostly determined by their own regional economic events. However, the global factor is the most relevant one to explain the exchange rate variability in Western Europe. This finding gives support to the central role of the European Union and reveals the effects of both the existence of a common currency and the monetary policy for the Euro Zone. Finally, country-specific factors are the most important ones in Central and Eastern Europe. This result is coherent with the variety of exchange rate regimes in these economies explained by both their structural diversity and their need to control exchange rates and inflation.

Finally, the paper shows empirical evidence in favour of the importance of the role of fundamentals in explaining the exchange rate global factor variability This evidence gives support to the connection between exchange rates and macroeconomic fundamentals, with the latter increasing their importance in the recent global crisis.

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