

## BEHAVIOR OF THE CENTRAL EUROPE EXCHANGE RATES TO THE EURO AND US DOLLAR<sup>1</sup>

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**Abstract:** Our objective has been to measure an impact of the two main global currencies - Euro and USD on shaping of exchange rates in countries of Central Europe. We have also endeavored to measure whether and to what extent a different approach to the Euro introduction as well as differentiated macroeconomic situation of these countries influenced the behavior of their exchange rates. The hitherto analyses indicate that the PLN rate of exchange was until 2004 strongly tied to the USD, but since 2004 links with the EUR exchange rate have become stronger. However the exchange rates of other countries in the region had been tied to the EUR earlier than the PLN exchange rate as they already had strong such links in the whole period of our analysis. Currency integration of the Central European countries is very strong although they are formally outside the euro zone and formation of their exchange rates should be perceived through trends of the EUR exchange rate versus other currencies, the USD.

**Key words:** exchange rate, Central European, cointegration analysis, euro zone

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## INTRODUCTION

Exchange rates belong to the most important variables in an open economy model. A mechanism for attaining a short-term equilibrium as well as effectiveness of fiscal and monetary policies depend to a large extent on mechanisms shaping exchange rates. An exchange rate may serve as a buffer for external shocks absorption<sup>2</sup>. At the same time the forex market is one of markets of crucial importance. Trading in this market is continuous, irrespective of time of the day, in any place in the world.

The exchange rate of any currency depends on many factors of complex nature, among which of great significance are those related to economic activity of business entities, movements of capital, migration of population, or to speculation. However, in last years an increasing role was played by the process of integration among states and resulting thus integration of economies. It is particularly noticeable in Europe where the Euro is a dominating currency. The rates of exchange formation in the global market are linked to the monetary policy of the state<sup>3</sup>, and ongoing empirical studies indicate only a short-term influence of macroeconomic factors, even if the latter are subject to considerable fluctuations<sup>4</sup>. In practice this may signify a strong influence of currencies used by well developed economies on the exchange rates of currencies of less developed countries. In the case of non-euro E.U states it may indicate subordination of their exchange rates to the European currency<sup>5</sup>.

This work is aimed at defining the impact of the two major global currencies i.e. the Euro and the U.S. dollar on formation of exchange rates in the countries of Central Europe: Czech Republic, Poland, Slovakia and Hungary. An attempt was also made to assess whether and to what extent different approaches to the introduction of euro, and differentiated macroeconomic situation in these countries impacted the behavior of exchange rates.

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<sup>2</sup> C. Goodhart, *Money, Information and Uncertainty*, Macmillan Press, London 1985, p. 430.

<sup>3</sup> J. Frenkel, *A Monetary Approach to the Exchange Rate: Doctrinal Aspects and Empirical Evidence*, *Scandinavian Journal of Economics*, 1978, Vol. 78, No. 2, p. 219 - 220.

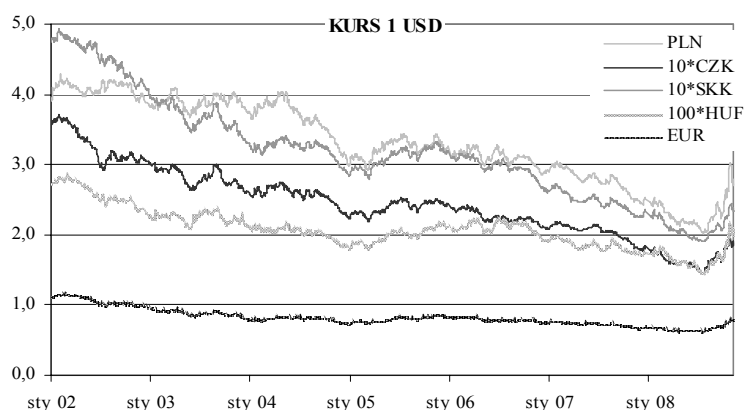
<sup>4</sup> R. Flood, A. Rose, *Fixing the Exchange Rate Regime: A Virtual Quest for Fundamentals*, *Journal of Monetary Economics*, 1995, Vol. 36, p. 33.

<sup>5</sup> F. Ravenna, *The European Monetary Union as a Commitment Device for New EU Member States*, European Central Bank, Working Paper No. 516, Frankfurt/Main 2005, p. 26.

## METHOD OF ANALYSIS

In this study we analyze foreign exchange rate formation of Central Europe currencies, i.e. the Polish zloty (PLN), Czech crown (CZK), Slovak crown (SKK), Hungarian forint (HUF) to the selected major global currencies: the US dollar (USD) and euro (EUR). To this end we use daily FOREX quotations in the years 2002-2008. The rates of exchange of the above mentioned currencies to the US\$ are presented in fig.1. and a similar trend in behavior of their value is noticeable. Subsequent peaks and bottoms fell on similar moments, the overall trend however indicates a regular appreciation of the analyzed currencies and depreciation of the US\$. In the last few months we observe the strongest adjustment - a reversal of the trend, i.e. a strengthening of the US\$ position against all currencies under study.

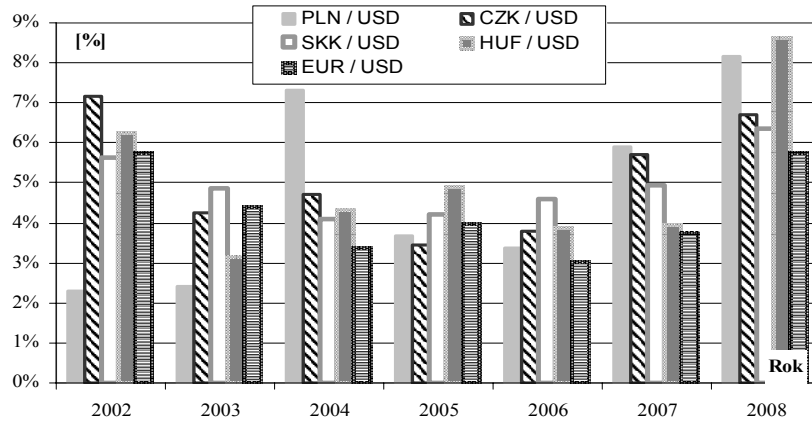
Figure. 1. Currency quotes 2002-2008 - 1 USD rate of Exchange 1 USD rate of exchange;  
Sty - Jan (January)



Source: FOREX quotes

Fig.2 shows annual volatility coefficients ( $V = s/\bar{x}$ ) of the exchange rates of analyzed currencies against 1 USD. Some divergences can be observed here and they concern mainly the PLN versus other currencies. We see that in the initial period - years 2002 and 2003 volatility of the PLN exchange rate to the USD was much lower than that of the other currencies of the region. In 2004 however, we witness a reverse phenomenon - volatility of the PLN exchange rate to the USD is much higher than that of other currencies. In years 2005-2007 the exchange rates of all the analyzed currencies were relatively stable, while in 2008 rates of exchange volatility significantly increased, as a result of the USD depreciation at the beginning of that year, and appreciation of this currency in the last month of that period.

Figure. 2. CV (volatility/variance) coefficient values- quotations 1 USD

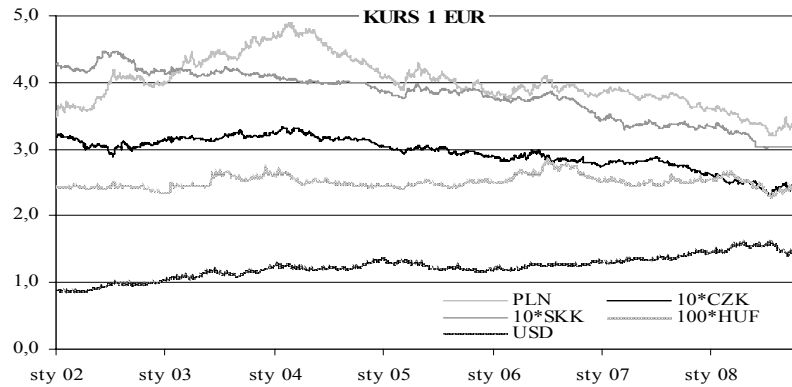


Source: own studies

The behavior of the exchange rates to 1 EUR was different (Fig 3). A common trend is hard to observe as the PLN showed a weakening trend till 2004 and then grew, CZK showed side-way movement till 2004 and then strengthened; SKK showed strengthening in the whole period while HUF showed side-way movement in the whole period; the USD had a weak trend for nearly the whole period and its strengthening has been noted in the last few months. Hence, the situation is different than in the formation of exchange rates to 1 USD.

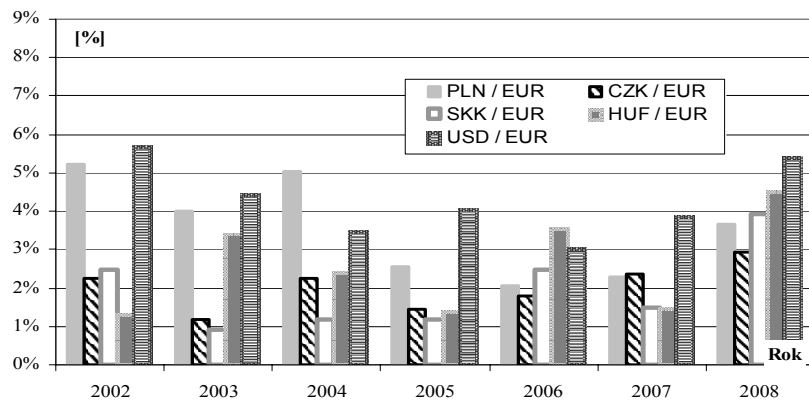
Fig 4 presents a collation of the exchange rates volatility coefficient against 1 EUR on annual basis. In comparison with volatility level against 1 USD, we may note a greater relative stability of the analyzed exchange rates against 1 EUR - coefficients show lower values, but on the other hand the observed trends are not that clear. Most stable behavior against 1 EUR was observed in the CZK and SKK exchange rates, while the HUF exchange rate movement was more volatile, the greatest volatility among currencies of the region was noted for the PLN rate which until 2005 had always been at higher level and only since that year maintained the volatility level similar to that of other currencies.

Figure 3. Currency quotations 2002-2008 -1 EUR exchange rate 1 EUR exchange rate;  
Sty – January



Source: FOREX quotations

Figure 4. Values of the exchange rate variance coefficient - 1 EUR quotations



Source: own studies

In the analysis of interrelations between time series values two methods the analysis of correlation and regression and the analysis of stationarity and co-integration, have been used in our study.

In the first part of our research the interrelations were measured between the rates of exchange in individual years and in the whole period under study using the Pearson's linear coefficient. However, as indicated by the research practice, these results may not be reliable due to such features as non-stationarity and heteroscedasticity of certain time series. Hence, analysis of correlation was supplemented by the study of stationarity and co-integration. In this respect, the first stage was an analysis of integration degree for individual time series of

exchange rates. To this end we used the Phillips-Perron test as well as the ADF (because of similarity results of the first test are presented here). A second stage of the analysis of stationarity and co-integration consisted in a construction of co-integrating equation and verification of the residual stationarity hypothesis. The following form of the co-integrating equation was used<sup>6</sup>:

$$y_t = a_1 x_t + a_2 t + c, \quad (1)$$

where:

$y_t$  - dependent variable;

$x_t$  - independent variable;

$t$  - time;

$c$  - constant.

The last stage of stationarity and co-integration analysis is construction of a model with an error correction mechanism of the form depending on the results of the first two steps<sup>7</sup>. In the case of level one stationary variables (stationary first differences of variables) co-integrated with each other, the autoregressive model based on the first differences with the error correction should look like:

$$\Delta y_t = c + \sum_{i=1}^{k-1} \theta_i \Delta y_{t-i} + \sum_{i=0}^{k-1} \gamma_i \Delta x_{t-i} + \alpha ECM_{t-1} + \varepsilon_t, \quad (2)$$

where:

$ECM_{t-1}$  - residuals from the co-integrating equation.

In the case of non-cointegrated variables an application of the autoregressive model without error correction would seem more appropriate. Before the analysis of stationarity and co-integration the logarithms of time series values were taken and thus a percentage interpretation of the equation 2 parameters made possible.

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6 A.W. Gregory, B.E. Hansen, Residual - based tests for cointegration model with retime shifts, *Journal of Econometrics*, 1996, Vol. 70, p. 99 - 126.

7 R.F. Engle, C.W. Granger, Cointegration and error correction: representation, estimation and testing, 1987, *Econometrica*, Vol. 55, p. 251 - 276.

## RESULTS

When comparing values of linear correlation coefficient of the exchange rates of regional currencies to 1 euro and the exchange rate of 1 euro to 1 USD (table 1) substantial similarities may be observed. All values of the correlation coefficient are positive i.e. EUR appreciation against USD results in the appreciation of other currencies, while depreciation involves the depreciation of these currencies. The above phenomenon is of different strength and for PLN in the period 2002-2003 it was weak, but grew strong in subsequent years, for CZK and SKK was strong in the whole period while for the HUF slightly weaker in the years 2003 and 2006, but remained always strong in other years.

Table 1. Correlation coefficients of exchange rates to 1 USD and the rate of exchange of USD to EUR

Pearson's correlation	EUR / USD							
	2002	2003	2004	2005	2006	2007	2008	from 1.05.04
PLN / USD	0.372	0.431	0.824	0.778	0.793	0.988	0.913	0.926
CZK / USD	0.961	0.963	0.907	0.929	0.987	0.969	0.901	0.946
SKK / USD	0.908	0.987	0.973	0.960	0.876	0.973	0.782	0.952
HUF / USD	0.983	0.634	0.838	0.972	0.488	0.929	0.870	0.921

Source: own calculations

Interrelations between the exchange rates of the currencies of the region vis-à-vis euro differ from those between the USD/EUR exchange rate. In the years 2002-2003 PLN is strongly linked with the USD, however already since 2004 most coefficients are negative. Exchange rates of other currencies in the region: CZK, SKK and HUF did not show strong links with the USD/EUR exchange rate in that period.

Table 2. Correlation coefficients of exchange rates to 1 Euro and the rate of exchange of 1 Euro to 1 USD

Pearson's correlation	USD / EUR							
	2002	2003	2004	2005	2006	2007	2008	from 1.05.04
PLN / EUR	0.906	0.836	-0.564	0.427	0.145	-0.918	-0.448	-0.757
CZK / EUR	-0.471	0.256	-0.453	0.504	-0.199	-0.800	-0.159	-0.808
SKK / EUR	0.207	-0.488	-0.581	-0.075	-0.434	-0.678	0.134	-0.831
HUF / EUR	-0.338	0.696	-0.144	-0.557	0.277	0.118	-0.364	-0.236

Source: own calculations

In our analysis of correlation (table 1 and 2) the period since May 1, 2004 was additionally singled out as the time when inter alia Poland, the Czech Republic, Slovakia and Hungary joined the European Union. In that period currencies of these countries linked themselves strongly to the EUR, as indicated by positive and close to unity values of the linear correlation coefficient in table 1 and negative values in table 2. If however, we discuss the strength of links with EUR, the strongest are those with SKK exchange rate, then with CZK, PLN and HUF.

In table 3 we see interrelations between the rates of exchange for the countries of the analyzed region to the USD and EUR. It turns out that the rates to the USD show a very strong positive correlation indicating thus a strong impact of the EUR/USD exchange rate on those relations, while those to the EUR are also positive but the HUF/EUR exchange rate has weak ties to the exchange rates of remaining currencies to 1 EUR, which may evidence a substantial autonomy of the Hungarian currency.

Table 3. Correlation coefficients of the CE region countries

Currency	PLN	CZK	SKK	HUF
PLN	-	0.983	0.965	0.834
CZK	0.947	-	0.979	0.827
SKK	0.892	0.934	-	0.867
HUF	0.114	0.040	0.170	-

Explanations: values above the diagonal - 1 USD exchange rate, values below - 1 EUR exchange rate.

Source: own calculations



The correlation study was supplemented by an analysis of stationarity and cointegration. Due to certain changes in the formation of the exchange rates after May 1, 2005 our study deals with time series since then. In general, all the analyses showed that the exchange rates were variables at the first integration level i.e. their first differences were stationary.

In the co-integrating equations presenting the exchange rate of regional currency to 1 USD with regard to EUR/USD, time and constant are very well aligned to empirical data as indicated by a high value of the determination coefficient, while residuals from these equations are stationary, as shown by the significance level of Phillips - Perron test being below 0.05 (table 4). It is then possible in accordance with the Engle-Granger's theorem to describe data with a model with an error correction mechanism.

Table 4. Co-integrating equation and the residual cointegration test-1 USD exchange rate

Currency	Independent variables			R2	Co-integration	
	EUR	trend	c		t	level
PLN	1.1372 0.0000	-0.0001 0.0000	1.5047 0.0000	0.9584	-3.5309	0.0004
CZK	1.1605 0.0000	-0.0001 0.0000	1.1912 0.0000	0.9753	-2.4921	0.0124
SKK	1.2497 0.0000	-0.0001 0.0000	1.4644 0.0000	0.9796	-2.1437	0.0309
HUF	1.3138 0.0000	0.0000 0.0000	0.9741 0.0000	0.8818	-2.7963	0.0051

Source: own calculations

Error correction models (Table 5) are marked by the relatively high, for increments models, values of determination coefficient and an absence of residuals autocorrelation. Coefficients values at the  $d(\text{EUR})$  variable equal approximately 1 i.e. the exchange rates of the Central European countries adjust overnight to the long-term equilibrium with the EUR to 1 USD exchange rate.

Table 5. Error correction model -1 USD exchange rate

Dependent variables d(X)	Independent variables				R2	level p (B-G)
	d(X(-1))	d(EUR)	d(EUR(-1))	ECM(-1)		
PLN	-0.0816	0.9690	0.3429	-0.0202	0.4866	0.0158
	0.0047	0.0000	0.0000	0.0006		
CZK	-0.0573	1,0762	0.0226	-0.0178	0.6514	0.0000
	0.0588	0.0000	0.5749	0.0021		
SKK	-0.2118	0.9352	0.3698	-0.0123	0.6606	0.0020
	0.0000	0.0000	0.0000	0.0192		
HUF	-0.1076	1,0192	0.2363	-0.0167	0.4834	0.0000
	0.0003	0.0000	0.0000	0.0027		

Source: own calculations

Analogous research was carried out for link-ups between foreign exchange rates of regional currencies to 1 EUR with USD/EUR. And similarly to the earlier analysis the exchange rates show themselves to be non-stationary but their first differences are of stationary nature (Table 6). The co-integrating equations, except for HUF are well adjusted to empirical data (Table 7). Residuals from each equation are stationary.

Table 6. Co-integrating equation and residual-based co-integration test - exchange rates to euro

Currency	Independent variables			R2	Cointegration	
	USD	trend	c		t	level p
PLN	-0.1380	-0.0001	1,5046	0.8509	-3,3411	0.0008
	0.0000	0.0000	0.0000			
CZK	-0.1829	-0.0001	1,1970	0.9046	-2,8478	0.0043
	0.0000	0.0000	0.0000			
SKK	-0.2512	-0.0001	1,4645	0.9315	-1,9998	0.0437
	0.0000	0.0000	0.0000			
HUF	-0.3144	0.0000	0.9741	0.1910	-2,6270	0.0084
	0.0000	0.0000	0.0000			

Source: own calculations

Models with an error correction mechanism for linking regional exchange rates to 1 EUR with the USD/EUR exchange rate do not have as good statistical properties as in the previous research. Here we observe low values of the determination coefficient and in the case of models d(PLN) and d(SKK) - autocorrelation of residuals. Taking into account the coefficient values with

independent variables only, we may notice low values with the  $d(\text{USD})$  variable and low values with the  $\text{ECM}(-1)$ , which means that the regional exchange rates to 1 EUR adjust very slowly to a long term equilibrium with the USD/EUR exchange rate, or do not remain there.

Table 7. Error correction model - exchange rate to euro

Dependent variables $d(X)$	Independent variables				R2	Level p (B-G)
	$d(X(-1))$	$d(\text{USD})$	$d(\text{USD}(-1))$	$\text{ECM}(-1)$		
PLN	0.0536	-0.1480	-0.0701	-0.0168	0.0459	0.9495
	0.0725	0.0000	0.0089	0.0007		
CZK	-0.0277	0.0402	0.0565	-0.0221	0.0163	0.0000
	0.3595	0.1132	0.0252	0.0003		
SKK	-0.0128	-0.0539	-0.0251	-0.0100	0.0116	0.1171
	0.6690	0.0011	0.1299	0.0174		
HUF	0.0175	-0.1422	0.0241	-0.0155	0.0313	0.0000
	0.5612	0.0000	0.4065	0.0021		

Source: own calculations

## SUMMARY

Our studies confirm in full the assumptions put forward in the introduction and indicate in particular that:

1. The PLN rate of exchange was until 2004 strongly tied to the USD, and since 2004 links with the EUR exchange rate have been stronger.
2. The exchange rate of other currencies in the region were tied to the EUR earlier than the PLN exchange rate, as in the whole period under study these ties were strong.
3. The Euro impact on regional currencies is very strong. Our study shows that any changes in the EUR/USD rate result in straightaway changes in exchange rates of other currencies of the region versus the USD.
4. The exchange rates of regional currencies versus euro are to a large extent shaped by other factors than USD / EUR exchange rate.

Notwithstanding the fact that formally the Central European countries are outside the euro zone, currency integration is very strong and formation of these countries exchange rates should be perceived through formation of the euro exchange rate towards other currencies, in particular to the USD.

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