13. THE DRIVERS OF THE CEE EXCHANGE RATE VOLATILITY - EMPIRICAL PERSPECTIVE IN THE CONTEXT OF THE RECENT FINANCIAL CRISIS[1]

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Abstract

This paper focuses on the CEE countries volatility captured by the exchange rate dynamics. In the first part, the spillover phenomenon is analyzed from the perspective of the recent financial crisis, where cross-border capital flows increased the risk of financial contagion. Volatility will be approached bi-dimensionally, from the perspective of the permanent and transitory dimensions. We conclude that volatility is of long-term nature in the CEE countries, with a certain degree of pecularity in terms of shock reaction.

In the second part, a research on the key determinants of the exchange rate volatility is conducted. Variables originating in financial markets were selected – EMBI spreads, Central Bank interest rate – as well as macroeconomic fundamentals – inflation, CROI index - in order to identify factors by which volatility pattern can be depicted.

The key result of the research points toward a deep correlation of the exchange rate volatility between the CEE countries and the Euro Zone, implying the necessity to develop strong financial management strategies at the macroeconomic level, capable of annihilating the transmission belt crisis mechanisms.

Keywords: volatility, component, transitory, permanent, spillover
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1. Introduction

Exchange rate volatility is perceived as a macroeconomic barometer. It represents the link between financial and real economy, being deeply rooted into the economic fundamentals.

The CEE countries have followed up a transition process, from fixed exchange rate regimes to flexible ones, most of them concentrating on the inflation targeting strategy. Moreover, exchange rate fluctuations represented an important source of volatility. The key issue is represented by the nature of the volatility, especially if it is determined by structural mutations, rooted into economic fundamentals or by intrinsic structures, specific to these countries.

Previous studies concentrated on the exchange rate volatility in both emerging [Pramor and Tamirisa (2006), Kobor and Szekely (2005), Horvath (2005)] and developed countries (Black and MacMillan, 2004). Analysts agreed on the fact that from both perspectives a volatility correlation reflected by the exchange rate dynamics can be assessed.

Horvath (2005) highlighted out that excessive exchange rate volatility triggers macroeconomic instability, perceived as a bad signal by investors. Thus, policy makers are preoccupied to limit exchange rate variability, even if this strategy might be unsuccessful in limiting the pressures on the foreign exchange market.

Hagen and Zhou (2005) pointed out that exchange rate volatility was perceived negatively, especially in the case of developing countries. Nevertheless, Calvo and Reinhart (2002) strengthened the ideas that fear floating was perceived also in developed countries, which would strive for exchange rate fluctuation reduction. Exchange rate volatility diminishes policy credibility, triggering economic crisis. This idea is worthwhile, especially in the context of the present financial crisis, when a high country indebtedness degree implies high exposure to currency and interest mismatches. Liquidity crisis determines default.

Exchange rate represents an essential anchor from the perspective of the policy makers' intervention into macroeconomic fundamentals. However, Borghijs and Kuijs (2004) presented evidence for the Czech Republic, Hungary, Poland, Slovakia and Slovenia that the exchange rate served "more as a propagator of monetary and financial shocks than as a useful absorber of shocks in real economy".

Devereux and Lane (2003) revealed some heterogeneity among the CEECs in terms of their exchange rate volatility and pressures. Specific features of emerging countries consist of higher exposure to external shocks, low turnover in the interbank foreign exchange market and few market makers.

Guimares and Karacadag (2004) analyzed exchange rate volatility in Mexico and Turkey from the perspective of central banks intervention. They concluded that in Mexico foreign exchange sales had an impact on the exchange rate level and determined short-term volatility increase, while in Turkey the effect was opposite.

Kobor and Szekely (2004) conducted a research on a sample of four countries – Poland, Hungary, the Czech Republic and the Slovak Republic – during a period of three years (2001-2003), revealing that volatilities were highly variable from one year to another. The key finding consists of similar exchange rate fluctuations during high volatility periods. Cross-correlations of currency pairs – the Polish zloty and the Hungarian forint, and the Czech koruna and Slovak koruna – increased significantly in high volatility periods. This idea was revealed also by Forbes and Rigobon (2000).

Pramor and Tamirisa (2006) highlighted out that the transmission of volatility shocks within the region have modified over time, except for the Hungarian forint, which “remained an important source of intraregional volatility shocks”. Our research confirms this assumption as well. Their study identified a lower degree of commonality within the CEE area, which is less than what Black and Millan found for major industrial countries in Europe before the introduction of the euro.

Altăr *et al*. (2008) analysed the impact that the exchange rate volatility also had on macroeconomic developments, finding a significant negative relationship between the monthly volatility of the Romanian leu against the euro, on the one hand, and the nominal and real exports and imports of Romania, on the other hand.

Melvin and Peiers (2003) argued that Asian volatility spills over into Europe and America, while American volatility spills over into Europe.

For the Romanian foreign exchange market, Ciurilă and Murăraşu (2008) find a significant dynamic correlation between the Romanian leu-euro exchange rate and the Polish zloty-euro exchange rate. Also, the volatility of the Romanian leu against the euro is found to be less persistent and more reactive to new information available than the Czech koruna against euro and the Polish zloty against euro exchange rates.

The methology of this paper originates in Pramor and Tamirisa (2006), Kobor and Szekely (2005), as well as in Black and MacMillan (2004), but what it differentiates it is exactly the deeper analysis performed at the level of the the two volatility components – transitory and permanent - on a more extended sample (including also Romania, Latvia and Croatia) during a larger period (January 1999-September 2008). We conceive volatility on a permanent basis in terms of temporary versus permanent components, revealing correlation of volatility dimensions both at intra and inter-regional level.

Our research follows up Guimaraes and Karacadag (2004) rationale, according to which volatility requires a peculiar approach to every emerging country, since research results ”can only be interpreted in the context of specific country circumstances”. Therefore, Principal Component Analysis will be applied both to transitory and permanent volatility components specific to every country.

The spillover phenomenon is analyzed from the perspective of the present financial crisis, where cross-border capital flows increased the risk of financial contagion. The key result of the research points towards a deep correlation at the level of the exchange rate volatility between the CEE countries and the Euro zone, implying the necessity to develop strong financial management strategies at macroeconomic level, capable of annihilating the transmission belt crisis mechanisms.

This paper is structured as follows. Section II depicts database and methodology, Section III includes C-GARCH estimation results and interpretation, Section IV analyzes spillover phenomena for the CEE countries, Sections V analyzes the determinants of exchange rate volatility patterns and Section VI concludes.

2. Data and methodology description

Our research is based on daily closing prices of CEE currencies (Czech koruna – CZK, Hungarian forint – HUF, Polish zloty – PLN, Slovak koruna – SKK, Romania leu – RON, Latvian lat – LVL, Croatian kuna – HRK) and euro, all quoted in US dollar rates, during a period of about eight years from January 1st 1999. The datasource is represented by European Central Bank site.

All the series presented unit root. Therefore, it was necessary to transform them into log-differences:

$$X_t = (ln((S_t)/(S_{t-1})))*100 \tag{1}$$

where: S_t represents the spot exchange rate.

Exchange rate volatility was approached within the generalized autoregressive conditional heteroskedasticity models (GARCH) framework elaborated by Engle and Bollerslev (1986) precisely in order to reflect the volatility clustering specifing to financial time series.

This model is depicted by the following equations:

$$X_t = a_0 + a_1*x_{t-1} + \varepsilon_t + b_1*\varepsilon_{t-1}, \qquad \varepsilon_t / I_{t-1} \in \mathbf{N}(0, h_t^2), \tag{2}$$

$$h_t^2 = q_t + \alpha_1*(\varepsilon_{t-1}^2 - q_{t-1}) + \gamma*(\varepsilon_{t-1}^2 - q_{t-1})*D_{t-1} + \beta_1*(h_{t-1}^2 - q_{t-1}) \tag{3}$$

$$q_t = \omega + \rho*q_{t-1} + \varphi*(\varepsilon_{t-1}^2 - h_{t-1}^2), \tag{4}$$

where: $D_t = 1$ for ε_t inferior to 0, $D_t = 0$ otherwise and ε_t represents the error term.

The first equation represents the mean equation, where x_t is the log-difference.

The term ε_t is supposed to be conditionally normally distributed, being dependent on past information and capturing any unexpected appreciation or depreciation.

The second and third equation reflect conditional variance (h_t^2), which is conceived as a linear function of a time-dependent intercept, the lag in the squared realized residuals (ARCH term), an asymmetric term (γ) and the lagged conditional variance (GARCH term).

This paper valorizes Component-GARCH (CGARCH) model, which breaks down volatility into two components, a permanent one and a transitory one. Permanent volatility component consists of a time-invariant permanent level (ω), an AR term (ρ) and the forecasted error (φ).

The short term volatility component is obtained by the substraction of the long term volatility out of the total volatility, meaning

$$h_t^2 - q_t = \alpha_1*(\varepsilon_{t-1}^2 - q_{t-1}) + \gamma*(\varepsilon_{t-1}^2 - q_{t-1})*D_{t-1} + \beta_1*(h_{t-1}^2 - q_{t-1}) \tag{5}$$

The forecasted error (φ) represents the difference between the lag in the squared realized residual and the forectast from the model (based on information available at time *t*-2). Engle and Lee (1993) reveal that CGARCH represents a GARCH (2,2) model, which is less restrictive than a GARCH (1,1) model.

The two volatility components are extracted by the intermediary of the CGARCH setup. Once the equation statistic output interpreted, the focus will be oriented towards the analysis of the volatility components by the intermediary of the Descriptive Statistics and PCA. These preliminary findings will serve as basis for spillover phenomenon explanation in order to point out financial contagion implications in the context of the actual financial crisis.

3. Empirical approach to volatility components for the CEE countries

The assymetric C-GARCH model has been valorized in order to estimate the two components of the volatility – long-run and transitory one (Table 1). As for all the countries, the coefficients corresponding to the long-run component are higher than the ones associated with the transitory component, which is in line with the findings of Pramor and Tamirisa (2006). Moreover, all the coeficients corresponding to the long-term component are significant in all the cases at 1%, reflecting the stability and appropriateness of the model to CEE countries.

In opposition to Pramor and Tamirisia (2006), the coefficients corresponding to the error term are in most of the cases negative, suggesting a lower shock impact on the permanent component of the volatility. This can be explained by the fact that the present database was extended also to the level of 2006, 2007 and 2008, where East Europen countries had a stabilized macroeconomic environment, characterized by national currency appreciation. Thus, transitory dimension of shocks is obvious. Owing to a more stabilized macro environment, characterized by economic growth specific to the catching up process, shocks are absorbed rapidly.

Table 1

Statistic output corresponding to the Assymetric CGARCH equation

		Croatia	Czech Republic	Hungary	Latvia	Poland	Romania	Slovakia
Intercept	ω	0.014733* (22.44875)	0.116980* (56.45521)	0.236413* (33.96697)	0.011840* (44.73832)	0.165118 (0.786221)	0.288622* (26.68601)	0.104709* (62.69708)
Permanent	ρ	0.773090* (15.49850)	0.750277* (4.160574)	0.869515* (27.22296)	0.870551* (32.12386)	0.941526* (13.00412)	0.912907* (6.065624)	-0.714573* (-13.82663)
ARCH term	α	0.242090* (7.218774)	0.032940*** (2.105776)	0.108012* (5.804890)	0.152247* (8.268688)	0.135983* (261.8737)	0.005797 (0.029738)	-0.289354* (-4.970219)
Asymmetric term	Ψ	-0.243340* (-9.062694)	-0.007151 (-1.018294)	-0.102255* (-6.399910)	-0.021698* (-3.159737)	-0.141546*** (-0.996631)	-0.004208 (-0.021745)	0.273689* (4.657455)
Garch term	β	0.523997* (46.09787)	-0.624951* (2.561961)	0.758677* (127.3504)	0.460098* (5.555219)	0.801802* (104.1541)	0.906420 (1.036677)	-0.452523* (-5.229175)
Error term	ξ	-0.007189** (-0.341343)	-0.036608*** (-2.121822)	-0.013946 (-1.789824)	-0.125405* (-6.491054)	-0.011251 (-0.996631)	0.004182 (0.227202)	0.057976* (6.084074)
	α + β	0.766087	-0.592011	0.866689	0.612345	0.937785	0.912217	-0.74188

*Notes: *Significant at 1%, **Significant at 10%, ***Significant at 5%. The numbers in parantheses reprezent T-Statistics.*
Source: Authors' own processing.

The only exceptions are Romania and Slovakia, for which coefficients corresponding to the error term are positive, suggesting shocks of long-term nature.

Permanent component coefficients are positive and higher than the ones corresponding to the transitory component, reflecting the fact that the permanent volatility component is stronger than the short-term one. Thus, volatility in CEE countries is definitely of long term nature.

The Czech Republic and Slovakia have a negative short term component (α + β inferior to 1), confirming the long-term nature of shocks (especially Slovakia).

The assymetric term is negative and significant (especially for Croatia, Hungary, Latvia and Slovakia), suggesting higher volatility in case of currency depreciation. Romania and the Czech Republic are the only countries where assymetric coefficient is non-significant, which is in line with the strong currency appreciation recorded during the four years.

Analysis at the level of the descriptive statistics corresponding to the volatility components reveal important aspects, generally in line with the finds of the CGARCH estimates (see Tables 2 and 3). In all the cases, the mean corresponding to the short-term component is lower than the mean corresponding to the long-term one, confirming the superior magnitude of the long-term component in comparison with the short-term one. The highest short term mean is recorded in case of Latvia while the lowest one belongs to Hungary.

Table 2

Descriptive statistics corresponding to the short-term component volatility

ST	Croatia	Czech Republic	Hungary	Latvia	Poland	Romania	Slovakia
Mean	-0.164	0.037	-0.295	0.299	0.216	-0.052	-0.135
Median	-0.263	0.116	-0.279	0.500	0.277	-0.030	0.011
Maximum	0.766	0.559	0.281	0.753	0.670	0.912	0.170
Minimum	-0.961	-0.983	-0.749	-0.570	-0.751	-0.957	-0.734
Std. Dev.	0.725	0.559	0.423	0.511	0.525	0.554	0.421
Skewness	0.245	-1.029	0.107	-0.812	-0.833	0.154	-0.834
Kurtosis	1.435	2.969	1.385	2.112	2.580	3.172	2.020
Jarque-Bera	0.784	1.059	0.773	1.000	0.861	0.036	0.623
Probability	0.675	0.588	0.679	0.606	0.650	0.981	0.732
Sum	-1.152	0.224	-2.067	2.098	1.513	-0.369	-0.541
Sum Sq. Dev.	3.157	1.567	1.074	1.569	1.653	1.843	0.534

**ST = transitory volatility component corresponding to every country.*
Source: Authors' own processing.

As for the long-term component, the highest mean is recorded in Poland case while the lowest one in case of Hungary. The same idea is supported by the maximum values of the long-term component which exceed the maximum values of the transitory one while the minimum values of the transitory component outperform the minimum values of the long term one. The highest short term component is encountered in Romania's case, while the lowest one is encountered in the Czech Republic's case. The highest long-term component was recorded in case of Hungary, followed up by the Czech Republic and Slovakia, while the lowest one was recorded in case of Croatia.

The transitory component appears to be more volatile than the permanent one. The standard deviation associated with the transitory component outperforms the ones corresponding to the long-term component. The most volatile transitory component belongs to Croatia while the lowest one to Hungary.

As for the long term component, Hungary appears to be the most volatile while Poland is the least volatile one. Romania holds a medium position in terms of transitory component volatility and almost the first position in terms of low long term volatility.

Table 3

Descriptive statistics corresponding to the long-term component volatility

LT	Croatia	Czech Republic	Hungary	Latvia	Poland	Romania	Slovakia
Mean	0.595	0.545	0.365	0.566	0.839	0.751	0.782
Median	0.716	0.621	0.642	0.522	0.892	0.912	0.809
Maximum	0.876	0.992	0.995	0.919	0.943	0.954	0.982
Minimum	-0.086	-0.088	-0.740	0.057	0.696	0.200	0.530
Std. Dev.	0.321	0.398	0.681	0.316	0.114	0.293	0.213
Skewness	-1.537	-0.517	-0.721	-0.362	-0.272	-1.148	-0.219
Kurtosis	4.049	2.039	1.916	1.893.	1.208	2.684	1.339
Jarque-Bera	3.077	0.499	0.949	0.510	1.022	1.567	0.491
Probability	0.214	0.779	0.622	0.774	0.599	0.456	0.782
Sum	4.167	3.271	2.559	3.963	5.876	5.263	3.131
Sum Sq. Dev.	0.621	0.795	2.787	0.602	0.078	0.515	0.137

** LT = long-term volatility component.*
Source: Authors' own processing.

Leptokurtosis appeared in the case of Romanian short-term and Croatian long-term component. The long-term component is negatively skewed for the whole sample, reflecting that on long term the CEE currencies followed an appreciation pathway.

The transitory trend is rightly skewed for Croatian, Romanian and Hungarian currencies, suggesting that on short term the tendency was a depreciating one. These currencies had the highest standard deviations in terms of transitory component, which is in line with the ideas depicted by Guimares and Karacadag (2004), who pointed out that in the case of Mexico and Turkey a higher volatility is associated with an exchange rate depreciation.

4. Spillover phenomena for the CEE countries

The connection between the CEE currencies and the Euro Area volatility was analyzed in order to reveal spillover phenomena. The correlation was analyzed at a bi-dimensional approach. Both CEE currencies intercorrelations and EUR and CEE currencies correlations were revealed (see Tables 4 and 5).

Considering the transitory component, the euro is positevely correlated to a high extent with the Croatian, the Czech and the Polish currencies and negatively with the Hungarian and the Romanian currencies.

Table 4

CEE currencies short-term volatility - pairwise correlation

ST	EUR	Croatia	Czech Republic	Hungary	Latvia	Romania	Poland	Slovakia
EUR	1.000	0.997	0.539	-0.637	-0.170	-0.623	0.656	0.790
Croatia	0.997	1.000	0.599	-0.691	-0.241	0.565	0.709	0.743
Czech Republic	0.539	0.599	1.000	-0.993	-0.922	0.323	0.989	-0.091
Hungary	-0.637	-0.691	-0.993	1.000	0.868	-0.665	-1.000	-0.030
Latvia	-0.170	-0.241	-0.922	0.868	1.000	-0.665	-0.855	0.470
Romania	-0.623	-0.565	0.323	-0.206	-0.665	1.000	0.182	-0.972
Poland	0.656	0.709	0.989	-1.000	-0.855	0.182	1.000	0.055
Slovakia	0.790	0.743	-0.091	-0.030	0.470	-0.972	0.055	1.000

Source: Authors' own processing.

Table 5

CEE currencies long-term volatility - pairwise correlation

LT	EUR	Croatia	Czech Republic	Hungary	Latvia	Romania	Poland	Slovakia
EUR	1.000	-0.443	0.168	0.158	-0.453	-0.789	0.240	-0.449
Croatia	-0.443	1.000	-0.057	0.485	0.201	0.753	0.040	0.651
Czech Republic	0.168	-0.057	1.000	-0.010	-0.065	-0.328	0.054	0.094
Hungary	0.158	0.485	-0.010	1.000	-0.182	0.236	0.146	0.558
Latvia	-0.453	0.201	-0.065	-0.181	1.000	0.896	-0.709	-0.769
Romania	-0.789	0.753	-0.328	0.236	0.896	1.000	-0.092	0.512
Poland	0.240	0.040	0.054	0.146	-0.709	-0.092	1.000	0.090
Slovakia	-0.449	0.651	0.094	0.558	-0.769	0.511	0.711	1.000

Source: Authors' own processing.

Negative correlation of a lower magnitude was remarked between the euro and the Latvian currency.

The magnitude of the long-term correlation between the euro and the CEE currencies is definitely lower in comparison with the one corresponding to the transitory component. The average correlation between the CEE currencies and the euro for the transitory component amounts to 60%, while for the long-term component it slightly exceeds 20%, which is consistent with Parmor and Tamirisia findings (2006), who pointed out that the correlation between the euro and the CEE countries is definitely lower than the one established between the developed countries and the euro, revealed by Black and McMillan since 2004.

The Romanian currency is positevely correlated with the Czech and Polish currencies and negatively with the Hungarian and Slovak currencies. The Croatian currency is positevely correlated with the Czech, Polish and Slovak currencies and negatively with the Hungarian and Romanian currencies. The Hungarian currency is negatively correlated to a high extent with the Czech and Polish currencies and positevely with the Latvian currency, which is strongly correlated in a negative manner with the

Czech currency. Positive correlations of a lower magnitude are remarked between the Latvian currency and the Polish and Romanian currencies.

As for the permanent volatility component, there is a negative correlation of about 45% between the euro and a group of countries formed by Croatia, Latvia and Slovakia, while the positive one includes euro and a group formed of the Czech Republic, Hungary and Poland.

Slovakia is slowly correlated in a negative manner with Hungary, Poland and the Czech Republic, while Croatia is positevely correlated with Romania, Slovakia and Poland. Latvia is negatively correlated to a high extent with Poland and Slovakia and to a lower extent with the Czech Republic. A high positive correlation was also established between the Latvian and Romanian currencies. Hungary is positively correlated with Slovakia and Croatia and negatively with the Czech Republic and Latvia.

Slovakia is slowly correlated in a positive manner with the Czech Republic, while the Romanian currency is positevely correlated at about 51% with Slovakia. Negative low correlation includes Polish, Czech and Romanian currencies.

In order to refine the perspective on the CEE currencies and EUR volatility, the Principal Component Analysis (PCA) was performed both for the transitory and long-term components (see Tables 6 and 7).

Table 6

PCA applied to CEE currencies and EUR short-term volatility

Compo-nents	**Comp1**	**Comp2**	**Comp3**	**Comp4**	**Comp5**	**Comp6**	**Comp7**	**Comp8**
Eigenvalue	2.82	1.62	0.94	0.74	0.67	0.58	0.48	0.19
Variance properties	68%	18%	15%	9%	7%	6%	4%	2%
Cumulative properties	68%	57%	78%	83%	92%	94%	98%	100%
Eigenvectors								
Variable ST	Vector1	Vector2	Vector3	Vector4	Vector5	Vector6	Vector7	Vector8
EUR	0.830	0.109	-0.337	0.088	0.139	-0.889	-0.341	-0.015
Croatia	0.437	-0.011	0.232	-0.081	0.110	-0.408	0.877	0.115
Czech Republic	0.066	-0.191	-0.005	0.133	0.130	0.063	0.011	0.733
Hungary	-0.050	0.111	0.046	-0.128	0.183	0.188	0.299	-0.100
Latvia	-0.070	0.614	0.352	-0.412	-0.198	-0.112	0.666	0.278
Romania	-0.138	-0.419	-0.514	-0.635	0.119	-0.024	-0.102	0.146
Poland	0.250	-0.539	0.645	-0.329	0.410	0.023	-0.113	0.641
Slovakia	0.166	0.310	-0.165	-0.519	0.132	-0.056	0.039	0.085

Source: Authors' own processing.

The PCA methodology is used for two purposes. First, it aims at identifying the peculiarities of the volatility components at the individual country level. Then, the methodology is extended to the country group level as well, focusing on potential relationships between volatility components characteristic to the CEE area. This second idea is reflected by the spillover phenomenon.

Table 7

PCA applied to CEE currencies and EUR long-term volatility

Compo-nents	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Comp7	Comp8
Eigenvalue	4.50	3.60	2.70	0.80	0.69	0.43	0.36	0.22
Variance properties	41%	23%	20%	17%	15%	11%	9%	4%
Cumulative properties	41%	53%	79%	83%	85%	89%	95%	100%
Eigenvectors								
Variable ST	Vector1	Vector2	Vector3	Vector4	Vector5	Vector6	Vector7	Vector8
EUR	-0.189	-0.102	0.725	-0.193	0.517	-0.332	0.162	0.155
Croatia	-0.171	-0.354	-0.302	-0.060	0.583	0.524	0.322	-0.188
Czech Republic	0.167	0.355	-0.088	-0.050	0.529	0.149	-0.716	0.150
Hungary	-0.402	-0.542	0.077	0.028	-0.126	-0.111	-0.576	-0.423
Latvia	-0.293	-0.063	-0.603	-0.043	0.209	-0.648	0.053	0.285
Romania	-0.325	-0.068	0.077	0.087	0.075	0.056	-0.197	-0.015
Poland	0.780	-0.578	-0.040	-0.128	0.092	-0.196	-0.054	0.088
Slovakia	0.227	0.329	-0.064	-0.345	0.211	-0.350	0.138	-0.806

Source: Authors' own processing.

The PCA permits an arrangement in terms of volatility peculiarities. The transitory dimension of the volatility reveals a bipolar structure of the first component formed by two groups, which include, on one hand, the euro, the Croatian, Polish, Slovakian and Czech currencies in line with Kobor and Szekely (2004) findings, and on the other hand the Hungarian, Latvian and Romanian currencies. The weights corresponding to the second group are more homogenously distributed.

As regards the second component, Latvia outperforms the other countries, pointing out that the Latvian currency reacts differently to shocks. On the third, fifth and eighth component this position is held by Poland and on the seventh component by Croatia.

Regarding the long-term component of the volatility, PCA reveals out the same bipolar structure on the first component, but with more closely distributed weights. In line with Kobor and Szekely (2005), the CEE currencies volatility tends to follow a similar pathway on long term.

On the fourth component, Romanian currency acts differently in comparison with the other currencies. The fifth and eighth component reveal out a very homogenous distribution of the weights values. On the seventh component, similar patterns are shown by Czech and Hungarian currencies, on one hand, and by Romanian and Polish currencies, on the other hand, consistent with Borghijs and Kuijs (2004) conclusions.

As Kobor and Szekely (2004) point out, Hungarian forint proved to be very volatile, mainly explained by the speculative attack in 2003.

In order to get a more profound perspective on the CEE intraregional spillover phenomenon, we reestimate the CGARCH model using in the equation for the permanent component of the volatility for a country the lagged estimated permanent components for the other countries.

$$r_{RO,t} = c \cdot \sigma^2_{RO,t} + \varepsilon_{RO,t}, \text{ with } \varepsilon_{RO,t} / I_{t-1} \sim N(0, \sigma^2_{RO,t})$$

$$\sigma^2_{RO,t} = q_t + a_1 \cdot (\varepsilon^2_{RO,t-1} - q_{RO,t-1}) + a_2 \cdot (\sigma^2_{RO,t-1} - q_{RO,t-1}) + a_3 \cdot (\varepsilon^2_{RO,t-1} - q_{RO,t-1}) \cdot D_{RO,t-1}$$

$$q_{RO,t} = \omega + b_1 \cdot (q_{RO,t-1} - \omega) + b_2 \cdot (\varepsilon^2_{RO,t-1} - \sigma^2_{RO,t-1}) + b_3 \cdot q_{j,t-1} \quad (6)$$

Statistical output pointed out that Hungary and Slovakia can be figured out as two important sources of spillover. The most significant volatility spillover effects are conceived from Poland to Hungary and from Latvia, Romania and Eurozone to Slovakia (see Tables 8 and 9).

Table 8

Spillover effects from the CEE countries to Hungary

From country i to Hungary	Coefficient b3	Standard error	Z-statistic	Probability
Poland	0.041	0.017	2.386	0.017

Source: Authors' own processing.

Table 9

Spillover effects from the CEE countries to Slovakia

From country i to Slovakia	Coefficient b3	Standard error	Z-statistic	Probability
Latvia	0.095	0.015	6.257	0.000
Romania	0.041	0.006	7.041	0.000
Euro Zone	0.003	0.004	6.129	0.000

Source: Authors' own processing.

5. What triggers the CEE exchange rate volatility pattern?

We analyze to what extent a series of variables capturing financial (central bank interest rate, EMBI spreads) and macroeconomic fundamentals (CROI index) can explain the CEE exchange rate volatility.

First, we examine the time series properties of the explanatory variables. Several tests for stationarity revealed the fact that all the underlying variables present unit roots. Therefore, it was necessary to apply the log to the first-differences.

We estimate the following fixed-effect panel regression model by OLS

$$X_t = \alpha_i + \beta_1 log(SPRD_{i,t}) + \beta_2 \, log(r_{i,t}) + \beta_3 \, log(CROI_{i,t}) + D_{it} + \varepsilon_{it} \quad (7)$$

where:

$X_{it} = (ln((S_t)/(S_{t-1})))$*100, S_t represents the spot exchange rate for country i at t;

$SPRD_{it}$ = *EMBI* spreads for country i at t;

r_{it} = the Central Bank interest rate for country i at t;

$CROI_{it}$ = Credit Rating Outlook Index for country i at t;

D_{1t} = Dummy variable which takes the value 1 if inflation rate exceeds 3% and 0 if inflation rate is inferior to 3% country i at t.

EMBI spreads are determined by JP Morgan on daily basis as as the difference between the yields of sovereign bonds issued by emerging economies and the yield for a bond issued by a developed benchmark economy. These spreads are designed to reflect the default risk of these countries.

The Credit Rating Outlook Index (*CROI*) transforms S&P ratings on numerical scale representations (see Table 10).

Table 10

Credit Rating Outlook Index

Category	S&P sovereign ratings	Outlook		
		Stable	Positive	Negative
Investment grade				
	AAA	1	0	2.7
	AA+	2	1	3.7
	AA	3	2	4.7
	AA-	4	3	5.7
	A+	5	4	6.7
	A	6	5	7.7
	A-	7	6	8.7
	BBB+	8	7	9.7
	BBB	9	8	10.7
	BBB-	10	9	11.7
Sub-investment grade, categoria I				
	BB+	11	10.1	12.7
	BB	12	11.1	13.7
	BB-	13	12.1	14.7
	B+	14	13.1	15.7
	B	15	14.1	16.7
	B-	16	15.1	17.7
	CCC+	17	16.1	18.7
Sub-investment grade, categoria II				
	CCC	18	18	18
	CCC-	19	19	19
	CC	20	20	20
	C	21	21	21
	SD	22	22	22

Source:Authors' own processing.

Table 11

Statistical model output

	Dependent variable - $ln((S_t)/(S_{t-1}))$			
Explanatory variables				
Macro fundamentals	**Coefficient**	**Standard error**	**T-statistic**	**P-value**
CROI	0.174	0.011	9.860	0.000
D1	0.042	0.018	4.270	0.000
Financial market fundamentals				
Central Bank Interest Rate	2.674	0.014	4.990	0.001
EMBI spreads	1.893	0.056	3.220	0.002
Other explanatory variables				
Constant	31.532	0.032	8.750	0.000
R squared	0.532			
Within	0.774			
Between	0.821			
Overall	0.798			

Source:Authors' own processing.

The associated p-values and T-statistics suggest that independent variables have a high explanatory power (see Table 11). The estimated coefficient for the CROI index points out that exchange rate volatility will increase by 0.1743 when the index value of the CROI increases by 1 unit in logs. Considering the case of Romania with a recent rating downgrade to BB^- and a negative outlook, when its rating falls by one notch to B^+ , the exchange rate volatility will increase by 17% (most likely under the form of a depreciation).

The dummy variable has an estimated coefficient of 0.0421, suggesting the fact that when inflation rate exceeds 3%, exchange rate volatility reaches almost 5%. Thus, the exchange rate volatility is deeply correlated with inflation, since currency exchange depreciation is usually accompanied by a high inflation rate.

The EMBI spreads have an estimated coefficient of 1.89, underling that 1% variation in EMBI spreads triggers a currency exchange volatility of 1.89.

Quite a higher impact on exchange rate volatility is embedded by the interest rate dynamics. A 1% increase in the reference monetary interest rate will determine an exchange rate volatility of 2.674.

All the coefficients are significant at 1%, suggesting that exchange rate volatility is determined to a significant extent by the set of explanatory variables.

The most significant impact is exerted by the financial related variables, especially by the Central Bank interest rate, followed up by the EMBI spreads, which are conceived as a proxy for investors attitude and by CROI index.

Exchange rate dynamics is impacted to a high extent by two key elements which are deeply connected with the rating agencies' analysis developed at country level – CROI and EMBI spreads.

This finding is in line with the assumption relative to the increasing impact deriving from financial flows internalization on the macroeconomic volatility. Perception induced by the rating agencies on the macroeconomic outlook correlated with the higher exposure to the financial globalization exerts a strong influence on the CEE exchange rate dynamics.

In the context of the actual financial crisis, CEE countries exposure to the internalization of the financial flows becomes a key macroeconomic volatility driver, especially from the perspective of the dependence on the foreign financing lines.

Even if international financial flows have contributed in a first stage to the catching up process which supported economic growth in the CEE countries, the actual financial crisis brings another perspective on this. Being dependent on the foreign financial flows, CEE countries face liquidity and default risk, which increases the macroeconomic volatility.

In order to refine the perspective on the impact exerted by the macroeconomic and financial market related variables on the exchange rate dynamic, there has been performed Granger causality test (see Table 12).

Table 12

Granger causality test statistic output

	F-statistic	Probability
Ln(S_t/S_{t-1}) does not Granger cause CROI	1.156	0.236
CROI does not Granger cause ln(S_t/S_{t-1})	12.060	0.004
Ln(S_t/S_{t-1}) does not Granger cause Central Bank interest rate	1.894	0.134
Central Bank interest rate does not Granger cause ln(S_t/S_{t-1})	14.030	0.001
Ln(S_t/S_{t-1}) does not Granger cause EMBI spreads	1.542	0.184
EMBI spreads does not Granger cause Ln(S_t/S_{t-1})	15.080	0.002

Source:Authors' own processing.

Statistical output highlights an impact deriving from the macroeconomic and financial market-related variables towards the exchange rate dynamics. The most consistent impact is originating in the EMBI spreads.

Granger causality runs one way, from the macro and financial related variables towards the exchange rate. Thus, exchange rate appears to be multidimensionally determined.

4. Conclusions

This paper focused on the CEE countries volatility captured by exchange rate dynamics. The spillover phenomenon has been analyzed from the perspective of the recent financial crisis where cross-border capital flows increased the risk of financial contagion. Volatility has been approached bi-dimensionally, from the perspective of the permanent and transitory dimensions.

Permanent component coefficients were positive and higher than the ones corresponding to the transitory component, reflecting the fact that the permanent volatility component is stronger than the short-term one. Thus, volatility in CEE countries is definitely of long-term nature, the transitory dimension of shocks being obvious. Owing to a more stabilized macro environment, characterized by economic growth specific to the catching up process, shocks are absorbed rapidly. The only exceptions are Romania and Slovakia, where coefficients corresponding to the error term are positive, suggesting shocks of a long-term nature. Therefore, we concluded that there is a certain degree of peculiarity in terms of shock reaction.

The transitory component appears to be more volatile than the permanent one. The standard deviation associated with the transitory component outperforms the ones corresponding to the long-term component. The most volatile transitory component belongs to Croatia while the lowest one to Hungary.

As for the long-term component, Hungary appears to be the most volatile while Poland is the lowest one. Romania holds a medium position in terms of transitory component volatility and almost the first position in terms of low long-term volatility.

Hungarian forint and Czech koruna have similar long-term volatility components, being driven by common shock factors. The strong spillover effects reflect a higher degree of CEE currency markets integration, with a negative impact on liquidity. Contrary to previous research (Horvath, 2005, Fidrmuc and Korhonen, 2004), Polish zloty is outperformed by Hungarian forint and Czech koruna in terms of spillover magnitude. The direction of the spillover effect figures out both currencies not only as spillover originators, but also as important shock absorbers, confirming the increasing financial flows between them and the other CEE countries.

The spillover phenomenon has been analyzed also at the level of the CEE currencies-euro interactions. The most significant spillover phenomenon has been remarked from euro to Hungarian forint, confirming the fact that the latter is the leading currency in the region from the perspective of the spillover phenomenon, being highly correlated not only with the other CEE currencies, but also with the euro.

Since at the intra-regional level the Hungarian forint has the highest magnitude in terms of spillover effect, we can conclude that from the perspective of the transmission mechanism the spillover at the level of the CEE currencies-euro interactions is indirect. The Hungarian forint being highly linked to all currencies, acts as a transmission belt of volatility impulses from the euro to the other CEE currencies. These findings are highly meaningful in the context of the present financial crisis, when countries are deeply interrelated through the financial flows globalization.

As for the exchange rate volatility drivers, the most significant impact is exerted by the financial related variables, especially by the Central Bank interest rate, followed up by the EMBI spreads which are conceived as a proxy for investors attitude and by CROI index.

Exchange rate dynamics is impacted to a high extent by two key elements which are deeply connected with the rating agencies analysis developed at the country level – CROI and EMBI spreads.

This finding is in line with the assumption relative to the increase of the impact deriving from financial flows internalization on the macroeconomic volatility. The perception induced by the rating agencies on the macroeconomic outlook correlated with the higher exposure to the financial globalization exerts a strong influence on the CEE exchange rate dynamics.

In the context of the present financial crisis, the CEE countries exposure to the internalization of the financial flows becomes a key macroeconomic volatility driver, especially from the perspective of dependence on the foreign financing lines.

Therefore, it is necessary to develop strong financial management strategies at the macroeconomic level, capable of annihilating transmission-belt crisis mechanisms.

The conclusions of this paper must be interpreted in the context of the approached pairwise correlations. For the period so far, important structural breaking points have not been remarked. Therefore, the analysis has not been developed at the sub-period level and this might be construed as a limitation. Future research will consider especially the last years - 2009 and 2010 - in order to capture the effects of the financial crisis on the CEE volatility.

References

Aghion, P., P. Bachetta, R. Ranciere and K. Rogoff, 2005 "Productivity Growth and the Exchange Rate Regime: The Role of Financial Development", *NBER Working Paper 12117.*

Altăr, Moisă, Necula, Ciprian and Bobeică, Gabriel, 2008, "Modeling the Economic Growth in Romania. The Influence of Fiscal Regimes", *Romanian Journal of Economic Forecasting*, pp. 146-160.

Bauwens, Luc, Sébastien Laurent, and Jeroen V.K. Rombouts, 2003, "Multivariate GARCH

Models: A Survey," *Center for Operations Research and Econometrics Discussion Paper, 2003/31* (Louvain-La-Neuve: Center for Operations Research and Econometrics).

Beveridge, Stephen, and Charles R. Nelson, 1981, "A New Approach to Decomposition of Economic Time Series into Permanent and Transitory Components with Particular Attention to Measurement of the 'Business Cycle'," *Journal of Monetary Economics*, Vol. 7, pp. 151–74.

Black, Angela J., and David G. McMillan, 2004, "Long-Run Trends and Volatility Spillovers

in Daily Exchange Rates," *Applied Financial Economics,* Vol. 14, pp. 895–907.

Bollerslev, Tim, 1986, "Generalized Autoregressive Conditional Heteroskedasticity," *Journal of Econometrics,* Vol. 31, pp. 307–27.

Bollerslev, Tim, 1990, "Modelling the Coherence in Short-Run Nominal Exchange Rates: A

Multivariate Generalized ARCH Model," *Review of Economics and Statistics,* Vol. 72, No. 3, pp. 498–505.

Bollerslev, Tim, and Jeffrey M. Wooldridge, 1992, "Quasi-Maximum Likelihood Estimation and Inference in Dynamic Models with Time-Varying Covariances," *Econometric Reviews,* Vol. 11, No. 2, pp. 143–72.

Borghijs, Alain, and Louis Kuijs, 2004, "Exchange Rates in Central Europe: A Blessing or a Curse?," *IMF Working Paper 04/2* (Washington: International Monetary Fund).

Byrne, Joseph P., and E. Philip Davis, 2005, "The Impact of Short- and Long-Run Exchange

Rate Uncertainty on Investment: A Panel Study of Industrial Countries," *Oxford Bulletin of Economics and Statistics*, Vol. 67, No. 3, pp. 307–29.

Calvo, Guillermo A. and Carmen M. Reinhart, "Fear of Floating," *Quarterly Journal of*

Economics, Vol. CXVII No. 2, May 2002, 379-408.

Ciurilă, Nicoleta, and Murăraşu, Bogdan, 2008. "Inflation Dynamics in Romania - a New Keynesian Perspective," *European Research Studies Journal,* vol. 4, pages 31-38.

De Grauwe, P. and G. Schnabl, 2005, "Exchange Rate Regime and Macroeconomic Performance in Central and Eastern Europe", *CESifo Working Paper* 1182.

Devereux, Michael B., and Lane, Philip R., 2003, "Understanding Bilateral Exchange Rate Volatility", *Journal of International Economics*, 60, pp. 107-112.

Dungey, Mardi, Renée Fry, Brenda González-Hermosillo, and Vance Martin, 2004, "Empirical Modeling of Contagion: A Review of Methodologies," *IMF Working Paper 04/78* (Washington: International Monetary Fund).

Engle, Robert F., 1982 "Autoregressive Conditional Heteroscedasticity with Estimates for the Variance of United Kingdom Inflation," *Econometrica*, Vol. 50, No. 4, pp. 987–1008.

Engle, R. F. and G. Lee, 1993, "A Permanent and Transitory Component Model of Stock Return Volatility," University of California - San Diego, *UCSD discussion paper, 92-44R*.

Fidrmuc, Jarko, and Iikka Korhonen, 2004, "A Meta-Analysis of Business Cycle Correlation Between the Euro Area and CEECs: What Do We Know—And Who Cares?" *BOFIT Discussion Paper No. 20,* Bank of Finland, BOFIT—Institute for Economies in Transition.

Forbes, Kristin, and Rigobon, Roberto, 2000, "Contagion in Latin America: Definitions, Measurement, and Policy Implications," *NBER Working Papers 7885*, National Bureau of Economic Research, Inc.

Guimarães, Roberto F., and Cem Karacadag, 2004, "The Empirics of Foreign Exchange Intervention in Emerging Market Countries: The Cases of Mexico and Turkey," *IMF Working Paper No. 04/123* (Washington: International Monetary Fund).

von Hagen, Jürgen & Zhou, Jizhong, 2006. "Fear of Floating and Fear of Pegging: An Empirical Analysis of De Facto Exchange Rate Regimes in

Developing Countries," *CEPR Discussion Papers 5530, C.E.P.R. Discussion Papers.*

Harvey, A., E. Ruiz, and N. Shephard, 1994, "Multivariate Stochastic Variance Models," *Review of Economic Studies, Vol. 60, pp. 99–111*.

Horváth, Roman, 2005, "Exchange Rate Variability, Pressures and Optimum Currency Area

Criteria: Implications for the Central and Eastern European Countries," *CNB Working Paper No. 8* (Czech Republic: Czech National Bank).

Klaassen, Franc, 1999, "Have Exchange Rates Become More Closely Tied? Evidence from a

New Multivariate GARCH Model," *Discussion Paper No. 9910*, Tilburg University Centre for Economic Research.

Kóbor, Ádám and István Székely, 2004, "Foreign Exchange Market Volatility in EU Accession Countries in the Run-Up to Euro Adoption: Weathering Uncharted Waters," *IMF Working Paper 04/16* (Washington: International Monetary Fund).

Melvin, M. and Peiers, B., 2003, "The Global Transmission of Volatility in the Foreign Exchange Market", *The Review of Economics and Statistics 85:3*.

Pramor, M. and Tamirisa, N.T., 2006 "Common Volatility Trends in the Central and Eastern European Currencies and the Euro"*, IMF Working Papers 06/206, International Monetary Fund*.

Reinhart, Carmen and Calvo, Guillermo, 2002. "Fear of floating" *MPRA Paper 14000*, University Library of Munich, Germany.

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