Statistical Properties of the CEE Stock Market Dynamics. A Panel Data Analysis[1]

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The importance of Central and Eastern European (CEE) stock markets grew after 1990 as they were gradually used as diversification instruments for the foreign investors as well as due to the general expectation of their integration within the European capital market. This development generated an increasing body of literature issued with the aim to analyze the properties of these markets both in terms of performance and integration on one hand and diversification and risk management on the other hand. The paper focuses on the stock market indices of ten emerging countries from the CEE region – Slovenia, Slovak Republic, Estonia, Latvia, Lithuania, Bulgaria, Czech Republic, Romania, Hungary and Poland –over the 1994-2006 period and aims at identifying the properties of their dynamics in a panel data analysis. We found evidence of stationarity for the returns of these indices and identified some common characteristics of these markets taken as a whole.

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1. Introduction

Located in countries with business activity that recorded rapid growth, but not succeeded to accomplish the properties of the developed status and usually characterized as potentially unstable, the emerging markets attracted the interest of researchers from the perspective of their significance for international institutional investors. Barry, Peavy III and Rodriguez (1998), Harvey (1995), Divecha, Drach and Stefek (1992), as well as Bekaert et al. (1998) are among the first authors to observe that these markets perform in a quite different manner as compared to developed markets. The literature evidenced a number of empirical regularities: high volatility, low correlations with developed markets and within emerging markets, high long-horizon returns, and more variability in the predictability power as compared to the returns of the stocks traded in the developed markets. It is also well evidenced that emerging markets are more likely to experience shocks induced by regulatory changes, exchange rate devaluations, and political crises.
The Central and Eastern European countries have suffered major shifts in their economic and political systems during their transition period to market economies. The stock exchanges that had been closed reopened in the 1990s. The main concern that equity markets would have difficulties to produce all of their benefits for a market economy due to factors like mistrust in their power to attract finance, low liquidity and high volatility, was materialized for some of these economies, while others succeeded to show important developments in these respects. The most important are the Polish, Hungarian and the Czech Republic. These stock exchanges show higher level of integration with the European capital markets.

The need for diversification tools raised questions concerning the inclusion of stocks belonging to Central and Eastern European markets in the international portfolios. The answer to these questions generated a growing body of literature aiming at investigating the properties of the European emerging markets and their persistence. On one hand, these initiatives generated results on the areas of the correlations of these markets with the developed ones under the analysis of their integration with the European capital markets. One result in this area is provided by the research initiated by Pajuste (2002), who observes that CEE capital markets are quite different in terms of their correlations with EU capital markets. While the Czech Republic, Hungary and Poland display higher correlations among them and with the EU market, Romania and Slovenia show inexistent or even negative correlation with the EU capital market. Analysis in this area are also realized by Horobet and Lupu (2009) and Lupu and Lupu (2009) showing the properties of these correlations with different techniques – cointegration and Granger causality tests on one hand and dynamic conditional correlations performed at the burst of the actual crisis on the other hand. In the same area, Classens et al. (2000) investigate the potential development of CEE capital markets and conclude that their future integration within EU will lead to their consolidation as well as to increased correlations with EU markets.
Groh and Liechtenstein (2009) investigate the attractiveness of the Central Eastern European markets for risk capital investors by constructing a tailored composite measure. They realized a survey in which they asked a representative sample of institutional investors from 27 European countries about the importance of certain asset allocation determinants when investing in emerging markets. Their results showed the degree of heterogeneity among the CEE countries in terms of capital markets development by comparison with the developed European markets and also provided information about the relevant factors lagging behind the European benchmark as well as recommendations for the policy decision makers.

The statistical properties of the returns for these stock market indices are analyzed in most of the papers. However, general properties have not been extracted and the research does not present so-called "stylized facts" for these types of markets, as for instance is the case for the developed capital markets, evidenced for instance by Cont (2000).

There is a lot of evidence on the fact that the stock returns are predictable. The predictability of the CEE markets is an issue yet to be tested using linear and nonlinear models. The nonlinearity of the patterns existing in the dynamics of the time series of the stock indices can be understood in many ways – from the differences acknowledged when compare the distributions for different frequencies of the returns to the process of mean reversion. The investigation of the nonlinear properties of the returns could be performed by simply trying to fit a series of nonlinear models and testing the properties of their residuals. The ability to capture the possible dynamic pattern of the series is an issue that is studied by many papers especially due to the fact that the nonlinear composure of the processes might be dependent on the specificities of the markets we are investigating. Hence, an analysis of the nonlinear properties of the CEE stock markets might reveal some of the particular dynamics of these markets.

Our paper contributes to the field of stock return properties by providing evidence about the comovement of these markets and the persistence of their characteristics. The rest of the paper is structured as follows: we make the presentation of the data and methodology employed, then we show the results and we conclude with some comments about the importance of our analysis and the future research.

2. Empirical Approach and Data

The study uses data on the stock market indices for 10 CEE countries (Slovenia, Slovak Republic, Estonia, Latvia, Lithuania, Bulgaria, Czech

Republic, Romania, Hungary and Poland). The data were obtained from Datastream. Table 1 provides summary statistics for the daily returns between 1994 and 2006. Daily returns are calculated as $r^i_{t,d} = ln(p^i_{t,d} / p^i_{t,d-1})*100$, where $p^i_{t,d}$ is the stock market index of *i-th* country, in year t on trading day d.

Table 1: Summary Statistics of Daily Returns of CEE and European Stock Exchanges

	Mean	Max	Min	Std. Dev.	Skew	Kurt.	Jarque-Bera	p-value
LBULX	6.101	7.577	4.256	0.980	-0.429	1.774	197.117	0.000
LCZEHX	6.523	7.568	5.756	0.507	0.699	2.054	471.805	0.000
LESX	5.600	6.950	4.434	0.718	0.235	1.684	264.762	0.000
LHUNX	8.591	10.313	6.576	1.112	-0.361	1.889	341.791	0.000
LLATX	5.777	6.639	4.605	0.579	-0.186	1.706	175.444	0.000
LLITX	5.317	6.383	4.146	0.739	-0.053	1.335	269.539	0.000
LPOLX	9.462	11.121	6.454	1.116	-1.280	4.162	1513.024	0.000
LROMX	7.532	9.289	5.639	1.131	0.070	1.481	283.023	0.000
LSLEX	7.803	9.358	6.409	0.697	0.412	2.173	235.915	0.000
LSLVX	5.225	6.230	4.251	0.608	0.216	1.705	271.714	0.000

As in previous research we notice the lack of normality for the series we analysed. However the variability of the skewness and kurtosis coefficients show that the distributions of these stock market indices are not similar. The most negative skewness is noticed in Poland, a market that is also accompanied by the highest level of kurtosis and the least normally distributed. Both the negative skewness coefficients and the high levels of kurtosis are evidenced by previous research on the statistical properties stock market returns.

The main contribution of our paper relies on the benefits of using panel data methodology to analyze the properties of the dynamics of the returns on the selected stock market indices. One can exploit the panel data structure of the database to undertake panel unit root test, since it has been shown that the power of unit root tests improves when one uses the extra information that can be derived from the additional observations (see Baltagi, 2005). The results from four panel unit root tests are presented: Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003) and the Fisher-type ADF test attributed to Maddala and Wu (1999) and Choi (2001). The Levin, Lin and Chu and Breitung tests both assume that there is common unit process while the Im, Pesaran and Shin and Fisher ADF allows the unit root process to vary across countries. All tests included an intercept with the lag length chosen based on the Modified Akaike Information Criterion (AIC) as proposed by Ng and Perron (2001).

There are two potential shortcomings of these traditional panel unit root tests: (1) cross-sectional dependence, and (2) non-linearity. We will use appropriate methodology to approach each of these two problems separately.

All of the above mentioned tests assume that the individual time series in the panel are cross-sectional independently distributed. However, in the case of CEE stock exchanges, this assumption is unlikely to hold. Indeed, Harrison and Moore (2009) find that CEE stock exchanges tend to exhibit a high degree of comovement, principally due to the effects of the developed markets of Western Europe. As previously mentioned, Lupu and Lupu (2009) also use dynamic conditional correlation methodology to show the contagion effect around the financial crisis of 2007. They found that the correlations of each pair of the same CEE countries stock indices as well as European composite MSCI indices are significant and stochastic, with important spikes during the crisis. To account for cross-sectional dependence, Pesaran (2007) proposes alternative unit root tests where the standard DF and ADF unit root regressions are augmented with the cross section averages of lagged levels and first-differences of the individual series. The cross-sectional augmented DF regression (CADF) is of the following form:

$$\Delta y_{it} = a_i + b_i y_{i,t-1} + c_i \bar{y}_{t-1} + d_i \Delta \bar{y}_{t-1} + e_{it} \tag{1}$$

where y_{it} is the stock price index in country i and period t, a_i is the country-specific effect, b_i, c_i and d_i are slope coefficients on various transformations of the stock price index and e_{it} is error term which is assumed to have normal properties.

Kapetanios et al. (2003) shows that in the presence of nonstationarity, standard unit root tests have very low power and fail to reject the null of a unit root. As a result, Cerrato et al. (2009) consider the case of stock prices being generated by the dynamic nonlinear heterogeneous panel ESTAR model:

$$\Delta y_{it} = v y_{it-1}[1 - \exp(-\theta_i y_{it-1}^2)] + \gamma_i f_t + e_{it} \tag{2}$$

where f_t is the unobserved common effect. The null hypothesis, that stock prices in CEE countries are non-mean reverting, is tested against the alternative that a stationary ESTAR model generates some stock prices (denoted by NCADF). Assuming that the unobserved common factor component can be proxied by the cross-section average, Ceratao et al. (2009) recommend using the following Im, Pesaran and Shin (2003)-type statistic:

$$\bar{t}_{NT} = N^{-1} \sum_{i=1}^{N} t_i(N,T) \tag{3}$$

where t_i is the t-statistic for b_i obtained from the following least squares regressions:

$$\Delta y_{it} = a_i + b_i y_{it-1}^3 + c_i \bar{y}_{t-1}^3 + d_i \bar{y}_t + e_{it} \quad (4)$$

$$\Delta y_{it} = a_i + b_i y_{it-1}^3 + c_i \bar{y}_{t-1}^3 + \sum_{j=1}^{p} \left(b_{ij} y_{it-j}^3 + c_{ij} \bar{y}_{t-j}^3 \right) + e_{it} \quad (5)$$

for the serially uncorrelated and correlated error case, respectively.

3. Results

The results for the four unit root tests on the panel data are presented in Table 2. The null hypothesis for the Levin, Lin and Chu test is that each individual time series contains a unit root, while the alternative hypothesis states that each time series is stationary. We can see that both the levels and the returns prove to be stationary for the panel composed of our ten indices. However, the results for Im, Pesaran and Shin test on the levels of the values for the indices show that we cannot reject the null that each time series in the panel contains a unit root but we could not find any results as far as the series of returns are concerned.

Table 2: Linear Panel Unit Root Statistics

	Levels	Returns
Levin, Lin and Chu	-3.094 [0.001]	-28.870 [0.000]
Im, Pesaran and Shin	-0.013 [0.495]	-
ADF – Fisher Chi-square	15.361 [0.755]	782.467 [0.000]
PP – Fisher Chi-square	14.479 [0.805]	184.207 [0.000]

Note: P-values are provided in square brackets below test statistics.

The Fisher type series both show that we can reject with virtually zero error the hypothesis that all the coefficients for the unit root coefficients are zero, which means that the series of returns show stationarity, while we cannot reject the hypothesis that all of the series of levels are stationary. These tests prove that the statistical properties on the basis of which further research could be elaborated are persistent.

Table 3 shows the results of the CADF and NCADF tests on each of the ten series of indices. We notice that the test with the serially uncorrelated errors show significance in the case of the Czech Republic, Hungary, Poland, Romania and Slovenia for both of the tests. However the tests with serially correlated errors show only a few of significance situations for the ten series of indices. In both of the instances, serially correlated and serially uncorrelated errors, we notice that the number of rejections of the null hypothesis of non-mean reversion is usually accompanied by the rejection of the hypothesis of cross section dependence.

Table 3: Individual Unit Root Tests for Non-Linear Mean Reversion and Cross-Section Dependence in CEE Stock Prices

	Serially Uncorrelated Errors		Serially Correlated Errors	
Country	CADF	NCADF	CADF	NCADF
Bulgaria	-1.790	-1.920	-1.556	-1.474
Czech Republic	-4.443***	-4.350***	-4.053***	-1.531
Estonia	-1.137	-1.008	-1.107	-0.641
Hungary	-3.916***	-4.109***	-2.604	-3.678**
Latvia	-1.934	-1.740	-1.519	-0.603
Lithuania	-0.934	-1.179	-2.049	-0.649
Poland	-4.105***	-4.384***	-3.370**	-3.360**
Romania	-3.282**	-3.688**	-3.250**	-3.005*
Slovenia	-5.393***	-5.878***	-3.461**	-5.190***
Slovak Republic	-1.132	-1.345	-1.270	-0.734

Note: The 1, 5 and 10 percent critical values for the CADF test are -3.81, -3.22, -2.91, while those for the NCADF test are -3.73, -3.12 and -2.82, respectively.

On the other hand, the performance of the same tests for the panel formed by the same ten series of indices show that we can reject the hypothesis of non mean reversion as well as the one of cross section dependence for the serially uncorrelated errors and only reject the cross section dependence for the serially correlated situation. Hence our analysis provides evidence on the fact our series are characterized by properties that are stationary, meaning that they can be used for forecasting and other type of analysis like the estimation of the risk of future dynamics.

Table 4: Panel Unit Root Tests for Non-Linear Mean Reversion and Cross-Section Dependence in CEE Stock Prices

	CADF	NCADF
Serially Uncorrelated Errors	-2.807***	-2.960***
Serially Correlated Errors	-2.424**	-2.087

Note: The 1, 5 and 10 percent critical value for the CADF test is -2.53, -2.32 and -2.21, while the values for the NCADF test are -2.50, -2.33 and -2.25.

The stationary ESTAR model that is evidenced by our tests provides information about the persistence of the statistical properties of the time series while the other test helps us keep track of the cross-section dependence of the series. The non-linear mean reversion is evidence of the fact that the modelling of the time series requires non-linear specification. Further investigation of these patterns might provide information about the properties of the returns of the stock indices for these markets.

4. Conclusions

This paper uses ten of the Central and Eastern European capital markets to test for the persistence of their statistical properties. On one hand, we are using the panel data technology to test for the stationarity of these series as a whole and on the other hand we are using individual and panel data to capture the ten capital market indices dynamics in terms of non-linear prediction and cross-section dependence.

The tests showed that the series are stationary especially in the case of the returns and that they show a great amount of non-linearity and cross-correlation, which is to be taken into account for further research in the areas of prediction or risk management.

Changing the frequency of the series might produce some information about other non-linear feature of the series. Also, the non-normality property of the series we investigated might as well be explained by the non-linear patter as well as by the interdependence of the capital markets taken in this region taken as a whole.

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