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Episodic dependencies in Central and Eastern Europe stock markets

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This article introduces a modified version of the Hinich and Patterson (1995) windowed-test procedure and uses it to detect linear and nonlinear dependencies in the case of six Central and East European stock markets. Testing the original methodology leads us to the same conclusions as those found on other emerging markets: relatively long random walk periods are interrupted by short and intense linear and/or nonlinear correlations. But, our findings diverge when we run the modified test procedure, additional windows rejecting the random walk hypothesis (RWH) being isolated. This divergence, heavily weighing the task of correctly evaluating the informational efficiency degree (the weak form), is significant for the Czech, Hungarian and Romanian markets.

I. Introduction

Random walks in stock returns are crucial to the formulation of rational expectations models and the testing of weak-form market efficiency. In an efficient market, stock prices fully incorporate all relevant information and hence stock returns will display unpredictable (or random walk) behaviour. The check of the RWH, being a joint and not a direct test of the efficient market hypothesis (EMH), leads us to the question whether the detected dependencies in stock prices can be used to earn abnormal rates of returns. In order to get a valid response two complementary research approaches are needed, one is identifying/modelling these dependencies and the other is studying their persistence in time.

Numerous recent studies have used the Hinich–Patterson windowed-test procedure (1995) to research the temporal persistence of linear and especially nonlinear dependencies. Thus, Ammermann and Patterson (2003), Lim et al. (2003), Lim and Hinich (2005) or Bonilla et al. (2006) are emphasizing the existence of different stock price behaviours, namely long random walk sub periods alternating with short ones characterized by strong linear and/or nonlinear correlations. All these studies suggest that these serial dependencies have an episodic nature being also the main cause for the low performance of the forecasting models.

The efficiency studies performed on Central and East European stock markets confirm, with few exceptions, the rejection of the RWH but none of them has checked to what extent the found dependencies are time persistent. Nivet (1997) finds evidence of market inefficiency in the early trading years of the Warsaw Stock Exchange. Studying the autocorrelation coefficients, he concludes that the RWH is rejected for those years. Chun (2000) and Worthington and Higgs (2004) researches also reject the RWH for the Polish, Czech an Russian stock markets, the Hungarian market being the only one to follow a random walk. According to Gilmore and McManus (2003), the significant autocorrelations found in some Central European stock markets are caused by both nonsynchronous trading and asymmetric response to good and bad news. By using a model-comparison test they also reject the RWH for all the stock markets included in

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the research. Schotman and Zalewska (2005) confirm that the predictability of the Central European emerging markets has decreased over time as the estimated time-paths of the autocorrelation coefficient gradually become indistinguishable from zero.

This article contributes to the existing literature by introducing a methodological innovation, as well as by highlighting the findings related to the informational efficiency of some Central and East European emerging stock markets.

II. Methodology

The sample, \{R(t)\}, is considered by the Hinich–Patterson methodology to be the realization of a stochastic process, where \( t \) (integer) is the time unit. The procedure implies the division of the \( N \) returns sample in \( NW \) nonoverlapped subsamples of volume \( n \), named windows, \( NW \) being the largest integer satisfying \( NW \leq (N!)/((n!)(n!)) \).

In each window, the null hypothesis is that \( R(t) \) is the realizations of a white noise process with null correlations and bi-correlations, described by \( C_{EE}(r) = E[R(t)R(t + r)] \) and \( C_{EE}(r, s) = E[R(t)R(t + r)R(t + s)] \), where \( r \) and \( s \) are integers satisfying \( 0 < r < s < L \) with \( L \) being the number of lags. Correlations identification is made using the portmanteau test (\( C \)) for linear correlations and the bicorrelation test (\( H \)) for the nonlinear ones. In order to compute them, a standardized series (\( Z(t) \)) is used:

\[
Z(t) = \frac{R(t) - m_R}{\sigma_R}
\]

where \( t \) takes values from 1 to \( n \) and \( m_R, \sigma_R \) are the mean and SD within each window. The correlations and bicorrelations are then given by:

\[
C_{RR}(r) = (n - r)^{-1/2} \sum_{i=1}^{n-r} Z(t)Z(t + r)
\]

\[
C_{RR}(r, s) = (n - s)^{-1} \sum_{i=1}^{n-s} Z(t)Z(t + r)Z(t + s)
\]

\[
0 \leq r \leq s
\]

The \( C \) and \( H \) statistics are distributed according to a \( \chi^2 \) law of probability with \( L \) respectively \( (L!)/2 \) degrees of freedom, having the following formulas:

\[
C = \sum_{r=1}^{L} |C_{RR}(r)|^2
\]

\[
H = \sum_{r=1}^{L} \sum_{s=r+1}^{L} G^2(r, s)
\]

\[
G(r, s) = (n - s)^{1/2} C_{RR}(r, s)
\]

The number of lags (\( L \)) is specified as \( L = n^b \), with \( 0 < b < 0.5 \). Hinich and Patterson recommends the usage of \( b = 0.4 \) in order to maximize the power of the test assuring in the same time a good asymptotical approximation. The window length must be long enough to offer a robust statistical power and yet short enough for the test to be able to identify the arrival and disappearance of transient dependencies, as changes in the variables behaviour (35 observations recommended). The rejection of the null hypothesis by the \( C \) and \( H \) tests is done with a determined risk level, generally 1 and 5%.

The Hinich–Patterson methodology does not allow an accurate identification of sub-periods exhibiting linear/nonlinear dependencies, because the test results depend on how the first day of the sample is chosen. The following example shows how the RWH can be accepted in the first window just because dependencies exist in a small time fraction of the windowed sub-period, while, if we considered the first day of the sample the last fraction of the first window, RWH is rejected.

A correct identification of the windows rejecting the RWH is essential for gaining a more accurate overview on the market efficiency degree (the weak form) and improves the significance of the efficiency evolution tests.

Thus, the ‘first day effect’ can be eliminated by running the Hinich–Patterson methodology in a successive way, considering the first day of the sample each of the first \( n-1 \) days from the first window. Due to the translation, each successive application eliminates a return from the last window making it insignificant. Theoretically, with the exception of the last return, each return from the first window can be considered with the same probability the starting point of the sample. Thus, for each sample, the percentage of significant windows (rejecting RWH) is given by:

\[
p(\%) = \frac{1}{n-1} \cdot \left( \frac{x_1}{NW} + \sum_{i=2}^{n-1} \frac{x_i}{NW - 1} \right) \cdot 100
\]

where \( x_i \) denotes the number of significant windows found on step \( i \).

III. The Data

The data consists of daily closing prices for six Central-East European stock market indices, the
starting day being given in brackets: Hungary (BUX, from 1 August 1991), Czech Republic (PX50, 14 September 1993), Slovakia (SAX, 4 July 1995), Poland (WIG, 7 January 1994), Romania (BET, 19 September 1997) and Russia (RTS, 4 September 1995). The last closing price for each index is 31 May 2006, the samples length varying between 2135 and 3850 observations. The data is transformed into a series of continuously compounded returns, \( r_t = \ln \left( \frac{P_t}{P_{t-1}} \right) \), where \( P_t \) and \( P_{t-1} \) denote two consecutive trading days.

IV. Empirical Results

We ran both the original Hinich–Patterson methodology and the modified one in the case of six major Central and East European stock markets using 35 observations for the window length, 0.4 for the \( b \) parameter and considering a risk level of 1% (we also developed a Pascal-based software solution to do the necessary data processing).

Using the original methodology we reached the same conclusions found on the Asian markets (Lim and Hinich, 2005) and those from Latin America (Bonilla et al., 2006), namely that the RWH is rejected by maximum 10% from the total number of windows. Moreover, we found significant differences between the markets, some indices like SAX and WIG having just one window rejecting the RWH while for the BET index we found nine such windows. It is also interesting to notice that we could not find any windows exhibiting nonlinear dependencies in the case of the Slovakian and Polish indices (The results are reported in Table 1).

Using the modified methodology, we found a significant increase of the proportion of windows rejecting the RWH in the case of the BET, BUX and PX50 indices and some originally inexistent nonlinear correlations for the SAX and WIG indices. The most radical change of behaviour is noticed in the case of PX50 where the RWH is rejected in 30% of its windows. As an exception, we could not find significant changes for the Russian index which means that the modified methodology does not necessary leads to a decrease of the market efficiency degree (The results are reported in Table 2).

V. Conclusions

This article uses the Hinich and Patterson windowed-test procedure and a modified methodology in order to isolate linear and/or nonlinear correlation

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<th>Table 2. The modified methodology-results</th>
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sub-periods from those accepting the RWH in the case of six indices from Central and Eastern Europe stock markets. In its original form, the methodology leads to the same conclusions reached on other emerging markets, namely that long sub periods of random walk are interrupted by short and intense sub periods with linear and/or nonlinear correlations, the intensity of these dependencies being different from market to market.

When the Hinich–Patterson methodology is used in a successive way, the proportion of windows rejecting the RWH substantially increases although this result is not a necessary consequence of the modified methodology, as we proved it. We found that by considering the ‘first day of the sample effect’ the results are different compared with the previous studies, additional sub periods rejecting the RWH being revealed.

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