THE BEHAVIOR OF STOCK MARKETS IN TRANSITION ECONOMIES – IS THERE A TRANSITION EFFECT?

Doc. Dr. Timotej Jagric
Faculty of Economics and Business, University of Maribor
timotej.jagric@uni-mb.si

Prof. Dr. Tanja Markovic Hribernik
Faculty of Economics and Business, University of Maribor
tanja.markovic@uni-mb.si

Vita Stajnko, univ. dipl. ekon.
vita.stajnko@uni-mb.si

Abstract

In the paper we investigate the properties of the stock markets in six transition economies: Slovenia, Hungary, Poland, Russia, Slovakia and the Czech Republic. We try to find out, whether the transition has some effect on the stock markets in the sense of Efficient Market Hypothesis (EMH). According to the empirical work done in this field we suggest methodology, which will be based on a new approach for testing the validly of the EMH. In contrast to other studies, we will not only test the EMH for the whole transition process, but also investigate whether the result are stable over time. This will probably give us some additional information on the transition process in the observed countries.

Key Words: *capital market, Hurst exponent, wavelet analysis, efficient market hypothesis, mechanical trading system.*

1 Introduction

Today, one can divide the research of capital and financial markets within the interdisciplinary field of econophysics roughly in two areas (Mantegna and Stanley 2000): the "microscopic" approach investigates the market dynamics from the point of view of the single agents, with the long-term target of being able to derive the complex "macroscopic" behavior of the markets from microscopic equations (Lux and Marchesi 1999). To thoroughly analyze the statistical properties of that "macroscopic" behavior is exactly what constitutes the second branch of econophysics (Baviera, Vergni, and Vulpiani 2000, Darbellay and Wuertz 2000, Molgedey and Ebeling 2000). This last field of research naturally profits in a special way from the immense amount of electronically recorded financial data available.

Following the second approach mentioned above, the present work will focus on the macroscopic properties of stock markets in transition economies. We will test, wether the stock markets follow the Efficient Market Hypothesis (EMH) in its weak form and if the hypothesis holds through the whole transition period. In order to get robust results we will employ two different approaches: estimation of the Hurst exponent and development of mechanical trading system. Finally, we will address the question of forecasting, and the interplay between determinism and stochasticity, both generally and referred to the observed situation on the selected capital market.

2 Analytical Framework

2.1 The long-range dependence phenomenon

The phenomenon of long-range dependence has a long history and has remained a topic of active research in the study of economic and financial time series (Gabaix, Gopikrishan, Plerou, and Stanley 2003). It is widespread in other areas in the physical and natural sciences (e.g., see Beran 1994 for details) and has been extensively documented in hydrology, meteorology and geophysics (see for example Mandelbrot and Wallis 1969). More recently, long-range dependence has also started to play an important role in the engineering sciences, especially in the analysis and performance modeling of traffic measurements from modern high-speed communications networks and semiconductor physics (for a recent bibliographical survey of this area, see Willinger, Taqqu and Erramilli 1996). It is commonly accepted that the definition of LRD is the slow power-law decrease of autocorrelation function o a wide sense stationary process expressed as

$$\gamma_x(k) \sim \mathrm{c}_\gamma k^{-(2-2H)}, \quad k \to +\infty \tag{1}$$

with $H \in (0.5,1)$, where $\gamma_x(k)$ is a covariance function and c_γ is a positive constant. The Hurst parameter H measures long range dependence. The LRD phenomenon is also closely related to the properties of scale invariance, self-similarity and hence fractals, and is therefore often associated with statistically self-similar processes such as the Fractional Brownian Motion

Due to the fact that the classical estimation procedure is sensitive to the statistical properties of a data set, a number of different versions of estimation procedures appeared in the literature. The algorithm applied in this paper will be based on a advanced wavelet version of the estimator, presented in Jagric et. al. (2005).

2.2 Mechanical Trading System

The second tool of our empirical work is based on technical analysis. This is a study of past prices. The efficient market hypothesis in her weak form says that all the information based on past prices movements are already included in current prices. If that is true, how could technical analysis make any profits, larger than normal? The idea isn't new. A test for weak form, based on trading or filter rules is common and often presented in books related to this topic, quantitative finance. Malkiel (2003) speaks in fawor of EMH: "Any success outperforming the market with technical analysis or fundamental analysis can be attributed to lady luck«. But there are traders who did realize big profits in trades based on either technical or fundamental analysis.

As there are many rules in technical analysis, we choose only most popular tools and commonly used among traders. To use them consistently and absolutely objective we used the help of computer programming. We created a mechanical trading system (MTS) in software package Matlab.

A mechanical trading system offers clear entry and exit signals. Trading systems remove the emotions that affect trading decisions. Mechanical trading systems also include risk control and money management. Commodity trading systems may be combined for greater diversification. Basically there are three kind of mechanical trading systems (Schwager 1998): trend following, countertrend and patterns recognition. Additionally we can list few more groups of mechanical trading systems: position trading systems, day trading systems, option trading systems, stock index trading systems, fixed income trading systems, energy trading systems etc.

MTS is a system which generates a response that indicates the appropriate action. Either to buy, sell, or do nothing depending upon the formulas the system uses. Mechanical trading systems also require trading in many markets. This is an attempt to reduce total portfolio risk. Simultaneous long and short positions in many markets can reduce total risk, but it dramatically reduces profitability.

For testing the EMH we created a MTS which relies on numbers of rules. The first task was the definition of trend even thou defining the trend is not easy. There is no universally accepted definition of a trend. Therefore, there is little agreement on how to follow the trend. If a recognizable trend was present MTS used simple moving average crossovers. A trading system using two moving averages would give a buy signal when the shorter (*faster*) moving average advances above the longer (*slower*) moving average. A sell signal would be given when the shorter moving average crosses below the longer moving average. The speed of the systems and the number of signals generated will depend on the length of the moving averages. Shorter moving average systems will be faster, generate more signals and be nimble for early entry. However, they will also generate more false signals than systems with longer moving averages. In our system we chose no extreme values: short moving average was a 15-day window, while the long one took 50-days. If the MTS couldn't identify a trend, signals have been created according to second tool. This part included rules that are appropriate for situations when market is on the side. We included Wilder's relative strength index (RSI) which is an extremely useful and popular momentum oscillator. The RSI compares the magnitude of a stock's recent gains to the magnitude of its recent losses and turns that information into a number that ranges from 0 to 100. It takes a single parameter, the number of time periods to use in the calculation. In his book, Wilder recommends using 14 periods. Additionally we included some safety rules such as liquidation of the position if the price falls 3% under the last buying price or that, whenever we sell, the whole quantity of stocks is liquidated. In figure 1 the chart of created mechanical trading system is presented.

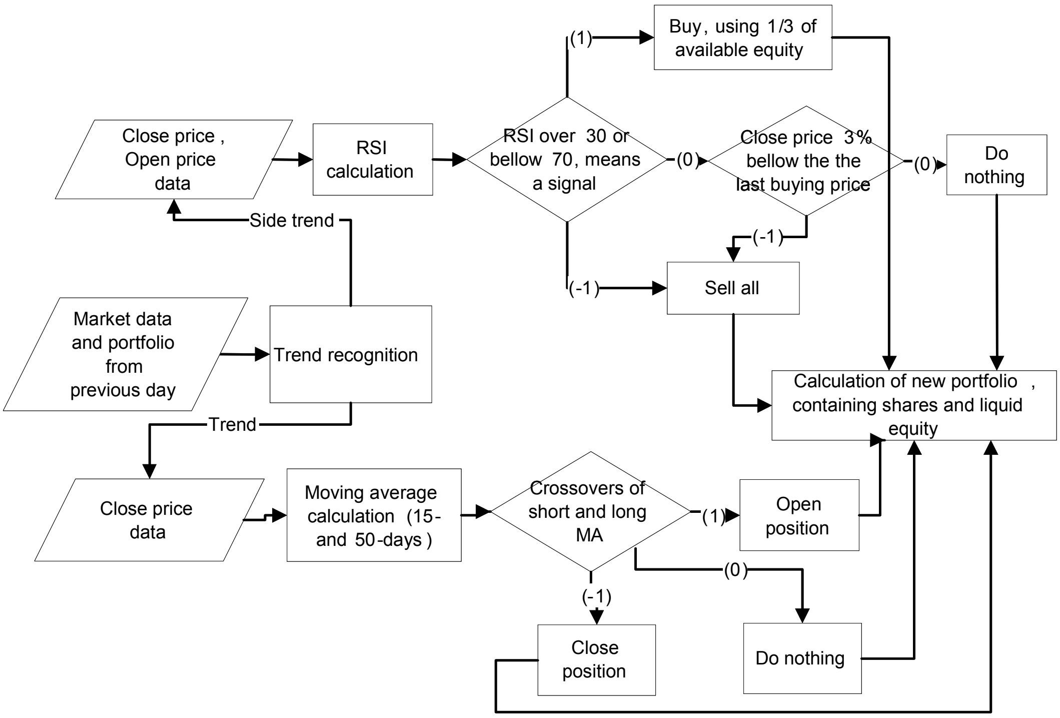

Figure 1: Mechanical trading system

3 Data

Since the main objective of this paper is the analysis of a selected capital markets in transition economies, we also need aggregate time series, which will represent the activity in the observed markets. As already indicated in the introduction, we collected the data for Czech Republic, Hungary, Poland, Russia, Slovakia, and Slovenia. We decided to use major stock market indices (PX50, BUX, WIG20, RTS, SAX, SBI). In order to capture the real dynamics of the market we use daily close values.

Most financial models do not attempt to model close values, but instead deal with returns on the instrument. This is heavily reflected in the literature of finance and economics (see, for example Mantegna and Stanley 2000). The return is the profit or loss in buying a financial instrument, holding it for some period of time and then selling it. The most common way to calculate a return is the log-return. Another way to calculate the return is to use the percentage return. Both transformations yield similar results in our analysis. Since the log-return is most frequently used in the literature, the results in this paper will be presented for this type of data.

4 Results

As already explained in section three, all indices are transformed into log-return format. Basic descriptive statistics for the financial data in the log-return format are presented in Table 1. Since both descriptive statistics (skewness and kurtosis) indicate deviations from normal values, we can expect that the observed distributions are not normally distributed. Therefore we calculated the Jarque-Bera statistic. In our case the results for all series indicate a rejection of the null hypothesis. Finally, we also performed a simple unit root test in order to test the stationarity of the selected series. We used the Augmented Dickey-Fuller (ADF) test. The results for the ADF test statistic are compared with MacKinnon critical values for rejection of hypothesis of a unit root at 1% significant level. In our case all series seem to be stationary - at least in the form, which is incorporated in the ADF test.

Table 1: Basic descriptive statistics for financial data

Country Index	Czech Republic PX50	Hungary BUX	Poland WIG20	Russia RTS	Slovakia SAX	Slovenia SBI
Mean	0.000145	0.000315	0.000081	0.000331	0.000020	0.000293
Median	0.000069	0.000197	-0.000081	0.000621	0.000000	0.000213
Maximum	0.066840	0.059132	0.064430	0.067563	0.041578	0.082225
Minimum	-0.032860	-0.078317	-0.102519	-0.091647	-0.049874	-0.050435
Std. dev.	0.006189	0.007227	0.009741	0.013245	0.006085	0.005967
Skewness	1.342059	-0.865260	-0.436134	-0.344032	-0.408682	0.416943
Kurtosis	17.177770	17.696320	11.924810	7.971277	9.488938	25.34591
Jarque-Bera	22270.17	30775.32	8476.89	2342.39	3928.12	60087.56
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
ADF test statistic	-20.030770	-25.360830	-21.477880	-20.291380	-21.190350	-21.688550
1% critical value*	-3.967100	-3.966300	-3.967100	-3.967600	-3.967600	-3.966700
Start date	07:09:1993	02:01:1991	18:04:1994	01:09:1995	03:07:1995	07:01:1993
End date	03:07:2004	30:06:2004	03:08:2004	05:08:2004	30:07:2004	16:07:2004
Observations	2567	3373	2530	2232	2204	2884

Note: *MacKinnon critical values for rejection of hypothesis of a unit root.
Source: calculations by authors.

After the examination of basic statistical properties of the selected time series, we can now perform the estimations of the Hurst exponent. The exponent was estimated for every series for ten different numbers of vanishing moments. This enabled us to test, if the estimations are stable and can be treated as reliable. Additionally we can also make some conclusions about the statistical properties based on the relation between the number of vanishing moments and the Hurst exponent.

The results for the estimated Hurst exponent are presented in Figure 2. The weighted average estimation of the Hurst exponent gives a surprising picture of the stock markets. The results indicate that we can make two groups of markets. In the first group are the markets where quiet strong long range dependence can be detected. This is the case for Czech Republic ($\overline{H}_{PX50} = 0.645 \pm 0.035$), Hungary ($\overline{H}_{BUX} = 0.626 \pm 0.030$), Russia ($\overline{H}_{RTS} = 0.648 \pm 0.039$), and Slovenia ($\overline{H}_{SBI} = 0.656 \pm 0.033$).The second group consist of markets where no or only extremely week form of long range dependence could be detected. This is the case for Poland ($\overline{H}_{WIG20} = 0.569 \pm 0.036$) and Slovakia ($\overline{H}_{SAX} = 0.525 \pm 0.039$).

Based on the weighted average estimates of the exponent, the strongest evidence for long range dependence was detected in Slovenia. Since Slovenian stock market is small in comparison to other markets in the group, this could be the reason for market inefficiency. This is also supported by the results for Poland, which is the largest stock market in the group and exhibits only extremely week form of long range dependence. However, the results for other countries do not support this hypothesis. We tried to find the explanation for these results in different measures of the market size (market capitalization, number of domestic firms listed, number of foreign firms listed …), however, none of the statistical measures could successfully explain the results. We think that the explanation of different behavior of the stock markets is more complex and involves the historical development, institutional regulations and the properties of the economic system.

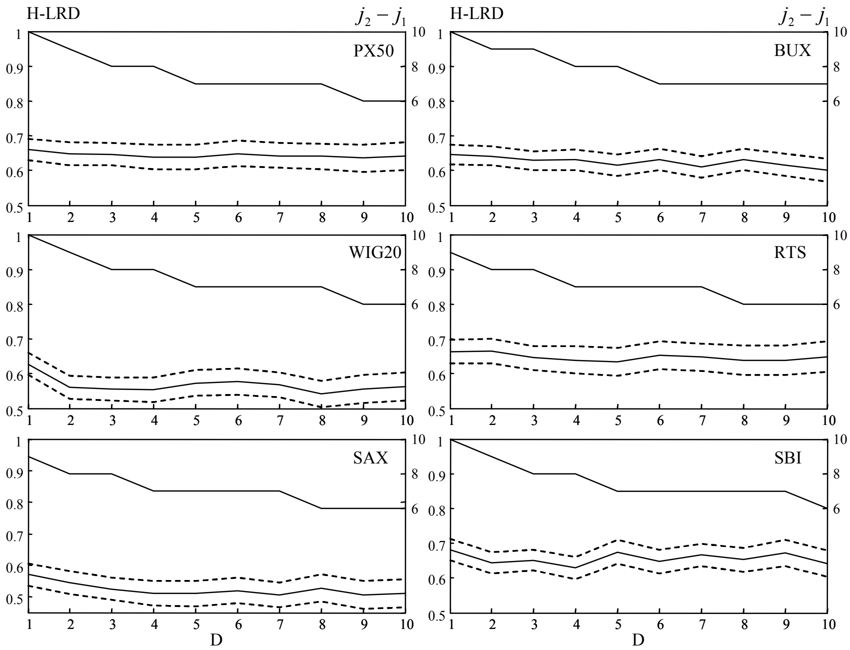

Figure 2: Estimated hurst exponent for the selected stock markets

Note: H-LRD – wavelet estimation of the Hurst exponent for different number of vanishing moments with 95% confidence interval, D – number of vanishing moments (type of the selected wavelet), $j_2 - j_1$ - number of octaves included in the estimation.

To additionally support the conclusions based on the estimation of the Hurst exponent, we also present the results for the developed mechanical trading system. Following the performance of the MTS presented in Table 2, we can conclude, that the second approach fully supports the conclusions based on the Hurst exponent. As one can see in the Table 2, only in the case of Slovakia and Poland, the MTS performance is lower than buy-and-hold strategy. In all other cases, the MTS outperformed the strategy, which guarantees normal returns.

As many studies suggest (Jagric 2003), the properties of the transition economies are changing. Therefore it is reasonably to assume that the Hurst exponent is not constant during the whole observed period. In order to test this hypothesis, we estimated the exponent on a sliding time-window of a size $T = 2^9$ for every stock market. The results are presented in Figure 3.

Table 2: Performance of both strategies

Market (Country name)	Index name	MTS performamce (in %)	Buy-and-hold (%)
Hungary	bux	1086	1046
Check Republic	px50	135.8	135.65
Russia	rts	1048	445.52
Slovakia	sax	8.1	16.16
Slovenia	sbi	794.4	593.83
Poland	wig20	59.65	61.56

Source: calculations by authors.

Graphs in Figure 3 reveal some interesting features. As expected, the exponent is not constant throughout the observed period. The only exception is Slovakia, where the exponent seems not to have any long-run direction of change. This can be explained by the fact that the average value of the exponent for the whole observed time period is already near 0.5 (random walk). In contrast to Slovakia, all other markets have clearly identifiable patterns in the changes of the estimated Hurst exponent.

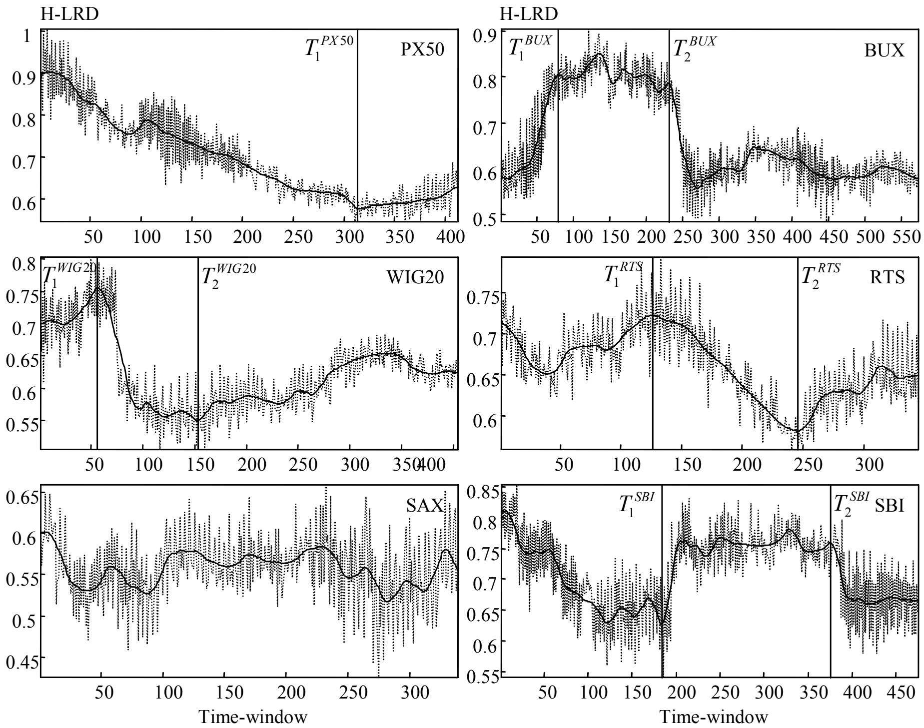

Figure 3: Estimated hurst exponent for the selected stock markets – sliding time-windows

Note: H-LRD – wavelet estimation of the Hurst exponent (dotted line – estimations, solid line – filtered values), window size = 2^9, time step = 5 trading days.

The results for Czech Republic indicate a clear tendency of lowering of the exponent. At the beginning the exponent was around 0.9. But the exponent did not remain at this level. Its value was constantly lowering up to the point T_1^{PX50} (21:08:2000-13:09:2002), where the exponent reached the minimum. After the point T_1^{PX50} exponent rebounded and slowly increased for the rest of the observed period. It is also important to note that the lowering of the exponent was interrupted in the time window from 07:02:1996 to 25:06:1998. During this time, the exponent slightly increased and also the volatility increased considerably. If we look at the history of Czech stock market, we can see that in the middle of this window (07:05:1997-25:08:1997) the Czech currency crises occurred. This can be an evidence for the influence of the currency crises on the behavior of the stock market participants.

The exponent for Hungary is most of the time around 0.6. The only exception is the time-span between the points T_1^{BUX} (08:07:1992-08:24:1994) and T_2^{BUX} (08:04:1995-08:18:1997) when the exponent increased drastically. The end of this period (point T_2^{BUX}) was marked by one important event – in January 1997 the foreigners are allowed to trade on the derivatives market of the stock exchange.

As in the case of Czech Republic, Russia, and Slovenia, the exponent for Poland was extremely high at the beginning of the observed period. It was even increasing up to the point T_1^{WIG20} (07:21:1995-08:08:1997). After the point T_1^{WIG20} the exponent sharply dropped and rebounded at the point T_2^{WIG20} (06:25:1997-07:15:1999). From this point on the exponent slowly increased for the rest of the observed period.

Estimated Hurst exponent for Russia was first around 0.7. Around the point T_1^{RTS} (12:03:1998-27:03:2000) the volatility of the exponent increased considerably. If we scan through history of the Russian stock market, we can identify one major event during this period – Russian currency crises. As in the case of Czech Republic, the crisis had an impact on the behavior of the market participants, since after the point T_1^{RTS} exponent dropped. The rebound occurred at the point T_2^{RTS} (02:08:2000-19:08:2002). After this point on the exponent increased again, however, it seems that the exponent stopped increasing as it reached the value of approximately 0.65.

With the beginning of normal trading on the Ljubljana Stock Exchange market, the SBI index indicates a presence of an extremely strong long memory process. The estimated value of the Hurst exponent is over 0.8. However, the nature of the index changed, since the value of the exponent was lowering up to the point T_1^{SBI} which represents a window from 27:08:1996 to 17:09:1998. In the middle of this window, there were some important changes on the Ljubljana Stock Exchange market. First, imposition of tax on capital gains deriving from trading in securities for domestic and foreign individuals (01:01:1997). Second, by the decree of the Bank of Slovenia, custody accounts are obligatory for all foreign portfolio investments. Furthermore these custody accounts and foreign currency reserves to the amount of funds on the account should appear on the balance sheet of the Slovene bank maintaining such an account (10:02:1997). Third, relaxation of limitations for foreign portfolio investors that were imposed by the Slovene central bank in February 1997. From this date on, the Bank allows foreign investors to buy Slovene securities without balancing foreign exchange position for the amount invested. Foreign investors have to undertake the obligation not to sell the securities for a period of 7 years (30:06:1997).

After the point T_1^{SBI} the estimated value of Hurst exponent increased again and reached the maximum at point T_2^{SBI} which represents a window from 26:06:2000 to

18:07:2002. As in the case of the point T_1^{SBI}, there were some important changes which took place in the middle of the time window. First, the stock exchange market segments A and B are merged into a single official market (01:01:2001). Second, Bank of Slovenia lifts all restrictions on foreign portfolio investments in the Slovenian capital market (01:07:2001).

The results for Slovenia and Hungary are similar and can be therefore treated as a strong evidence of the influence of foreign investors on the domestic capital market. It seems to us, that market becomes more efficient, if there are no restrictions for the foreign investors.

As already mentioned, most of the stock markets exhibit large values of the exponent at the beginning of the observed time period. We think that the lack of adequate infrastructure, physical and legal, as well as poor disclosure of accurate information, are possible explanations of inefficiency. Most of these institutional failures in transition economies have been removed in recent years, which may be the reason for lower values of the exponent at the end of the observed period. However, the management control systems are still not as effective as the control systems observed in more developed capital markets. Given the short life of these equity markets, market imperfections in these transition economies can be a source of inefficiency as they interfere with the rapid processing of information.

One important characteristic of some East European equity markets, which can be of direct relevance to the theory of efficiency, is the existence of some price restrictions on price movements. Such price limits certainly hinder the information transmission mechanism as the price can only go down once the ceiling is reached. These regulations may promote inefficiency by encouraging investors to base their investment decisions simply on the presence of regulations alone.

Conclusions

In the paper a wavelet analysis of long range dependence and mechanical trading system are applied. The estimator of the Hurst exponent can be implemented very efficiently allowing the direct analysis of very large data sets. The estimator is also highly robust against the presence of deterministic trends as well as allowing their detection and identification. The estimator is used to perform a thorough analysis of the long range dependence in the capital markets of six transition economies: Czech Republic, Hungary, Poland, Russia, Slovakia, and Slovenia. The results are supported by the performance of the mechanical trading system.

Peters (1992) suggests that a Hurst exponent value $0.5 < H < 1.0$ shows that the efficient market hypothesis is incorrect - returns are not randomly distributed, there is some underlying predictability. The results in this study are mixed. If we estimate the exponent for the whole observed period, we can divide stock markets into two groups. The first group represents the stock markets where quiet strong long range dependence is detected (Czech Republic, Hungary, Russia, and Slovenia). These are similar results as in the case of S&P 500 (Peters 1992) and seven Asia Pacific stock markets (Pandey et al. 1995). The second group represents the stock market, where no or only a weak form of long range dependence was detected (Poland and Slovakia).

However, if the Hurst exponent is estimated on a sliding time-window, the results show some additional features about the observed stock markets. Most of the stock markets exhibit excessively high values of the exponent at the beginning of the observed period. In most cases important events on the markets triggered the process of lowering of the exponent. These are not only events like currency crises, which had also influence on foreign markets, but also changes in institutional regulations.

References

Baviera, R., Vergni, D., and Vulpiani, A. 2000. Markovian approximation in foreign exchange markets. *Physica A* 280: 566-581.

Beran, J., *Statistics for Long-Memory Processes*, Chapman & Hall, New York, 1994.

Darbellay, G.A., and Wuertz, D. 2000. The entropy as a tool for analysing statistical dependences in financial time series. *Physica A* 287: 429-439.

Gabaix X, Gopikrishan P, Plerou V, Stanley H.E. 2003. A theory of power-law distributions in financial market fluctuations. *Nature* 423: 267-270.

Jagric, T. 2003. A Nonlinear Approach to Forecasting with Leading Economic Indicators. *Studies in Nonlinear Dynamics and Econometrics* 7: 0-19.

Jagric, T., Podobnik, B., and Kolanovic, M. 2005. Does the Efficient Market Hypothesis Hold? Evidence from Six Transition Economies. *Eastern European Economics* 43(4): 85-110.

Lux, T., and Marchesi, M. 1999. Scaling and criticality in a stochastic multi-agent model of a financial market. *Nature* 397: 498-500.

Malkiel, Burton G. 2003. The Efficient Market Hypothesis and Its Critics. CEPS Working Paper No. 91. Princeton University.

Mandelbrot, B., and Wallis, J. 1969. Computer Experiments with Fractional Gaussian Noises: Part 3, Mathematical Appendix. *Water Resources Research* 5: 228-267.

Mantegna, R.N., and Stanley, H.E. 2000. *An Introduction to Econophysics: Correlations and Complexity in Finance*. Cambridge University Press. New York, USA. 148.

Molgedey, L., and Ebeling, W. 2000. Intraday patterns and local predictability of highfrequency financial time series. *Physica A* 287: 420-428.

Pandey, V., T. Kohers and G. Kohers 1995. Chaotic Determinism in the Stock Returns of the Major PAcific Rim Equity MArkets and the U.S. Paper presented at the 1995 *Eastern Finance Association Meeting* in Hilton Head, South Carolina, U.S.A.

Peters, E. E. 1992. R/S Analysis Using Logarithmic Returns. *Financial Analysts Journal 23*: 81-82.

Schwager, Jack D. 1998. Getting Started in Technical Analysis. New York: John Wiley & Sons.

Willinger, W., Taqqu, M.S., and Erramilli, A. 1996. A bibliographical guide to self-similar traffic and performance modeling for modern high-speed networks. In *Stochastic networks: Theory and applications*, Kelly, F.P., Zachary, S., and Ziedins, I. (eds.) Clarendon Press, Oxford.