# The Fractal Market Analysis and Its Application on Czech Conditions[#]

## *Tran Van Quang*[*]

## Introduction

For more then last 30 years concept Efficient Market Hypothesis (EMH) has been the bedrock of quantitative capital market theory and dominated the field of research on this subject. The EMH has only one primary function: to justify the use of probability calculus in analysing capital markets. And no concept in investment finance has been as widely tested and little believed as efficient market. The results of various studies in the world have shown that the market may not behave efficiently and the conditions, under which markets behave efficiently may not be fulfilled. For example, if the markets are nonlinear dynamic systems, then the use of standard statistical analysis can give misleading results, particularly if a random walk model is used. Therefore, it is important to reevaluate the premises that underlie current capital market theory. One of such attempts is the Fractal Market Analysis (FMA) concept. FMA is using rescaling range *(R/S)* analysis to distinguish fractal from other types of time series, to reveal the self-similar statisical structure and to deal with conflict between randomness and determinism. This article is divided into four parts. In part 1, the summary of EMH is provided. Part 2 deals with the gist of the article: the Fractal Market Analysis. In part 3, FMA is tested on the Czech equity price index (the PX50). The final part of the article is the conclusion.

## 1. The EMH summary

Efficient markets are priced so that all public information, both fundamental and historical, is already discounted. Prices, therefore, move only when new information is received. An effective market can not be gamed because not only do the prices reflect known information, but large number of investors will ensure that the price are fair. In this regard, investors are considered to be rational: they know, in a collective sense, what information is important and what is not. Then after digesting the information and assessing the risks involved, the collective consciousness of the market finds an equilibrium price. Essentially, the EMH says that the market is made up of too many people to be wrong.

If the safety in numbers assumption is true, then today's change in price is caused by today's unexpected news. Yesterday's news is no longer important, and today's return is unrelated to yesterday's return, that is the returns are independent. If returns are independent, then they are random variables and follow a random walk. If enough independent price changes are collected, in the limit, the probability distribution becomes the normal distribution. This assumption regarding the normality of returns opens up

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a large battery of statistical tests and modelling techniques, which may help descision maker to achieve an optimal solution. And this is the random walk version of the EMH. In many way, it is the most restrictive version. Market efficiency does not necessarily imply a random walk, but random walk does imply market efficiency. Therefore, the assumption that returns are normally distributed is not necessarily implied by efficient markets. However, there is a very deeply rooted assumption of independence. Most tests of the EMH also test the random walk version. In addition, the EMH in any version says that past information does not affect market activity, once the information is generally known. This independence assumption between market moves is especially important for random walk theory, and then to more general martingale and submartingale models. Although not all versions of the EMH assume independence, the techniques used for statistical testing have independence assumptions, as well as built in finite variance. Because of these characteristics, the random walk version of the EMH is the one generally reffered to as the EMH, although technically this is not true.

## Development of the EMH

The original work using statistical methods to analyse returns was published in 1900 by L. Bachelier (2000), who applied to stocks, bonds, futures, and options the methods created for analysing posibilities of winning the gambling. Bachelier's paper was the work of pioneering foresight, many years ahead of its time. Among its accomplishments was the recognition that the Wiener process is Brownian motion.

Bachelier's thesis was revolutionary, but largely ignored and forgotten. Application of statistical analysis to the markets languished until the late 1940s. Progress then became rapid. A body of work that became the basis of the EMH was collected by Cootner in his classic volume The Random Character of Stock Market Prices (2000). Cootner's work deals with market characteristic and presents the rationale for what was to be formalized as the EMH in the 1960s.

The claim that stock price follow a random walk was expressed first by Osborne. He offered a process in which changes in stock market prices can be equivalent to the movement of a particle in a fluid. Fama (1965) finally formalized all previous observations into the Efficient Market Hypothesis (EMH), which states that the market is a martingale, or fair game, that information cannot be used to profit in the marketplace and returns follow a random walk. The random walk model says that future price changes could not be inferred from past price changes. Random walk theory was an attack on technical analysis. The EMH took a step further by saying that, in its semi-strong form, current prices reflected all public information – all past prices, published reports, and economic news – an attack on fundamental analysis as well. The current prices reflected this information because all investors had equal access to it nad being rational, they would, in their collective wisdom, value the security accordingly. Thus investors, in aggregate, could not profit from the market because the market efficiently valued securities at a price that reflected all known information.

As said afore, there are many problems and the EMH cannot deliver satisfactory answers. Before the Efficient Market Hypothesis was fully formed, exceptions to the normality assumption were being found. Osborne plotted the density function of stock market returns, and labeled the returns approximately normal. And there were extra observations in the tails of the distribution, which caused the tail of the curve fatter and, this phenomena is now called a curtosis problem. But Osborne did not see their significance. Later the problem was discussed widely, but the distribution still was supposed to be Gaussian-like with fat tails.

The first complete study on daily returns was done by Fama (1965), who found that returns were negatively skewed: more observations were in the left hand tail than in the right hand tail. In addition, the tails were fatter, and the peak around the mean was higher than predicted by normal distribution, a condition called leptocurtosis. It means that when large movements occur, they might have been more often crashes than rallies and there are more small movement around the mean than normal distribution has.

Besides the problem of the so called anomalies, the large changes in stock prices, there is also a liquidity problem. Investors come to the marketplace to sell or buy what they want and the price is set up by system of supply and demand. Liquidity enables them to realize those transactions. Liquidity is generated by realizing transactions between investors who may have different investment horizons. When market is liquid, price can be close to a fair price, but when there is a lack of liquidity, market may become unstable and market participants may finish the trade at any price they can, fair or not, and that why the EMH cannot explain crashes and stampedes.

Another problem is the influence of investment horizons on assessment of the information sets. With a little simplification, but not far from reality, we can say that on the marketplace short-term investors primarily follow technical analysis and long-term investors are more likely to follow fundamentals. One procent change in return may not play such a significant role for long-term investors, but it may be a very good opportunity for short-term investors to participate the trade. And liquidity is then dependent on the type of information that is coming through the market and on which investment horizon investors find them important.

## 2. The Fractal Market Hypothesis

### 2.1. What is a fractal

In general, mankind is used to smoothness and symmetry and looks for patterns and symmetry everywhere thus imposes patterns where none exists and denies patterns that do not conform to the overall conceptual framework. This antagonism has its roots back in the ancient Greeks when Euclid tried to reduce nature to pure and symmetric objects: the point, the one-dimensional line, the two-dimensional plane, and the three-dimensional solid. Solids have a number of pure symmetrical shapes, such as spheres, cones, cylinders nad blocks. None of these objects has holes in it and none is rough.

In reality, nature does not usually exists in symmetry and natural objects are not symmetrical as well. Using Euclidean geometry to describe nature, natural objects usually look artificial and unnatural. With fractal geometry, the geometry of imperfection and asymmetry, we can describe natural objects more naturally and more realistic. So, what is a fractal?

*No one, even Mandelbrot (1997), who is considered as the father of fractal geometry, can give a precise definition. But we can roughly say that a fractal is a rough or fragmented geometric shape that can be subdivided in parts, each of which is at least and approximately a smaller copy of the whole. Fractals are generally self-similar (bits look like the whole) and independent of scale (they look similar, no matter how close you zoom in).*

Fractals have certain characteristics that are measurable and desirable for modelling purposes.

The first one is self-similarity, which implies the definition of a fractal that the parts are some what related to the whole. For example, a tree is a natural fractal object. Tree grows according to fractal scale. So it branches and each branch, with its smaller branches, is similar to the whole tree.

In real life, the self-similarity is in a quantitative sense. It means that the object or process is similar at different scales, spatial or temporal, statistically. Each scale resembles the other scales, but it is not identical. Individual branches of a tree are qualitatively self-similar to the other branches, but each branch is also unique. This self-similarity makes the fractal scale invariant: it lacks a characteristic scale from which the others derive.

The second property of fractal geometry is that fractals have noninteger dimension. As said afore, a point has no (zero) dimension, a line is one-dimensional, a plane is two dimensional and a solid is a three-dimensional. The fractal dimension characterizes how the object fills its space. In addition, it describes the structure of the object as the magnification factor is changed or how the object scales. For geometric fractals, this scaling law takes place in space. A fractal time series scale statistically, in time.

The fractal dimension of a time series measures how jagged the time series is. As said above, a straight line has a fractal dimension of one, a plane has a fractal dimension of two. Therefore, the fractal dimension of a time series may be ranged from 1 to 2. A fractal dimension of a time series can be calculated from Hurst exponent $H$. (see 2.3.) Peters (1991) proposed that it should be the inverse of the Hurst exponent. Later, a common consensus about a fractal dimension of a time series among researchers was accepted and it should have value of $2 - H$.

## 2.2. Fractal Market hypothesis

The Fractal Market Hypothesis emphasises the impact of liquidity and investment horizon on the behaviour of investors. To make the hypothesis as general as possible, it will place no statistical requirements on the process. Markets exist to provide a stable, liquid environment for trading. Investors wish to get a good price, but that would not be a fair price in the economic sense. For instance, short covering rarely occurs at a fair price. Markets remain stable when many investors parcitipate and have many different investment horizons. When a five minute trader experiences a six sigma event, an investor with a longer investment horizon must step in and stabilize the market. The investor will do so because, within his or her investment horizon, the five minute trader's six sigma event is not unusual. As long as another investor has a longer trading horizon than the investor in crisis, the market will stabilize itself. Therefore, investors must share the same risk levels, and this is the reason of the similarity of returns distribution at different investment horizons and for this part the hypothesis is called Fractal Market Hypothesis.

Markets become unstable when fractal structures falls apart. It happens when investors with long investment horizons either stop parcitipating in the market or become short-term investors themselves. Investment horizons are shortened when investors feel that long-term fundamental information, which is the basis of their market valuations, is no longer important or is unreliable. Period of economic or political crisis, when long-term outlook becomes highly uncertain, probably accounts for most of these events.

This type of instability is not the same as the bear markets. Bear markets are based on declining fundamental valuation. Instability is characterized by extremely high levels of short-term volatility. The final result can be a substantial fall or rise, or a price equivalent

to the start – all in a very short time. However, the former two outcomes seem to be more common then the latter.

The fractal statistical structure exists because it is a stable structure, much like the fractal structures existing in nature as an example of a tree above. In the markets, the range of statistical distributions over different investment horizons plays the same function. As long as investors with different investment horizons are parcitipating, a panic at one horizon can be absorbed by the other investment horizons as a buying or selling opportunity. However, if the entire market has the same investment horizon, then the market become unstable. The lack of liquidity turns into panic.

When the investment horizon becomes uniform, the market goes into "free fall", e.g. discontinuities appear in the pricing sequence. In a Gaussian environment, a large change is the sum of many small changes. However, during panics and stampedes, the markets often skip over prices. The discontinuities cause large changes and fat tails appear in the frequency distribution of returns. Again, these discontinuities are the result of lack of liquidity caused by the appearance of a uniform investment horizon for market participant.

Another explanation for some large events exists. If the information received by the market is important to both the short-term and long-term horizons, then liquidity can also be affected. For example, if some bad news comes to the market and long-term investors may react to the news too pessimistic, by then the short-term investors may step in to stabilize the market.

Even when the market has achieved a stable statistical structure, market dynamics and motivations change as the investment horizon widens. The shorter the term of investment horizon, the more important technical factors, trading activity and liquidity become. Investors follow trends and one another. Crowd behaviour can dominate. As the investment horizon grows, technical analysis gradually gives way to fundamental and economic factors. Prices, as a result, reflect this relationship and rise and fall as earnings expectations rise or fall. Earning expectations rise gradually over time. If the perception is a change in economic direction, earnings expectations can reverse rapidly. If the market has no relationship with the economic cycle, or if that relationship is very weak, then trading activity and liquidity will dominate on the market even at long horizons.

If the market is tied to economic growth over the long term, then risk will decrease over time because the economic cycle dominates. The economic cycle is less volatile than trading activity, which makes long-term stock returns less volatile as well. This would cause variance to become bounded.

Finally, information itself would not have a uniform impact on prices. Instead, information would be assimilated differently by the different investment horizons. A technical rally would only slowly become apparent or important to investors with long-term horizons. Likewise, economic factors would change expectations. As long-term investors change their valuation and begin trading, a technical trend appears and influences short-term investors. In the short term, price changes can be expected to be noisier because a general agreement on fair price, and hence the acceptable band around fair price, is a larger component of return. At longer investment horizons, there is more time to digest the information, and hence more consensus as to the proper price. As a result, the longer is the investment horizon, the smoother the time series is.

## 2.3. Fractal *(R/S)* analysis

When building a dam on the Nile River in Egypt, Hurst had to deal with the inflow and outflow of the river to calculate the storage capacity of the dam. It seemed to be a random process. But after having studied almost one thousand year record of the overflow of Nile, it did not appear to him random. There appeared to be nonperiodic cycles but standard analysis revealed no statistically significant correlations between them, so he developed his own methodology.

Hurst was aware of Einstein's work on Brownian motion, the primary model for random process. It is found that the distance of a random particle increases with the square root of time used to measure it or :

$$R = T^{0.50}, \tag{1}$$

where $R$ – the distance covered and $T$ is time period.

Equation (1) is called the "$T$ to the one half rule" and it is commonly used in financial economics to annualize volatility or standard deviation. Using this property, Hurst could test the Nile River's overflow for randomness. From the studied time series the corresponding cumulative time series was created and the adjusted range of the series in the maximum minus the minimum value of cummlative time series was created too.

This adjusted range is the distance that the system travels for unit time period $T$ in equation (1) in Brownian motion. For time series that are not Brownian motion, equation (1) has to be generalized and it has to take into account systems that are not independent. Hurst found the more general form of equation (1) as follows:

$$\frac{R}{S} = c \cdot T^{H}, \tag{2}$$

where $S$ – the standard deviation of period $T$, $H$ is the so called Hurst exponent and $R/S$ is referred to as rescaling range.

The $R/S$ value is called the rescaling range because as will be seen later, it has zero mean and it is expressed in term of local standard deviation. In a time series the range increases with increments of time. By rescaling the data to zero mean and standard deviation of one, diverse phenomena and time periods can be compared. Rescaled range analysis also can describe time series that have no characteristic scale.

The Hurst exponent can be approximately calculated by plotting the log*(R/S)* against the log*(T)* and solving for the slope using an ordinary least squares regression:

$$\log\left(\frac{R}{S}\right) = \log(c) + H \cdot \log(T). \tag{3}$$

If a system were independently distributed, then $H = 0.50$. Hurst found for the overflow of the Nile River $H = 0.91$. It means the rescale range was increasing faster the the square root of time, which means that the system was covering more distance than a random process would. In order to cover more distance, the changes in annual Nile river overflows had to be influencing each other. They had to be correlated.

Interpretations of Hurst exponents

According to the original theory, *H = 0.50* would imply an independent process. Because *R/S* analysis does not require that the underlying process be Gaussian, just independent, it would include all independent processes.

*0.50 < H  1.00* implies a persistent time series, and a persistent time series is characterized by long memory effects. Theoretically, what happens today impacts the future forever.

*0  H < 0.50* signifies antipersistence. An antipersistent system covers less distance than a random one. For the system to cover less distance, it must reverse itself more frequently than a random process.

## 3. Testing FMH on Czech equity price index PX50

The FMH was tested on Czech equity price PX50 data. The daily PX50 data set was applied to *R/S* analysis over the period of more than 11 years from September 7th 1993 to October 20th 2004. The whole data set includes 2607 daily closing prices adjusted for dividends and splits. The *R/S* analysis is quite a simple process, but highly data intensive. The implementation of *R/S* analysis includes following sequential steps:

1. the time series of given length *M* is converted into a time series of length *N = M-1* of logarithmic ratios:

$$N_i = \log\left(\frac{M_{i+1}}{M_i}\right), \quad i = 1, 2,..., M\text{-}1, \tag{4}$$

2. the time period of *N* is divided into *A* contiguous subperiods of length *T,* such that $A \cdot T = N$. Each period is labeled as $I_a$, with *a = 1, 2, ..., A*. Each element in $I_a$ is labeled $N_{j,a}$ such that *j = 1, 2, ..., T*. For each $I_a$ of length *T,* the average value is defiened as:

$$e_a = \frac{1}{T} \cdot \sum N_{j,a}, \quad \text{for } j = 1, 2,..., T, \tag{5}$$

where $e_a$ – average value of the $N_i$ contained in subperiod $I_a$ of length *T*.

3. the time series of accumulated departures $(X_{j,a})$ from the mean value for each subperiod $I_a$ is defined as:

$$X_{j,a} = \sum (N_{j,a} - e_a), \quad \text{for } j = 1, 2,..., T, \tag{6}$$

4. the range is defined as the the maximum minus the minimum value of $X_{j,a}$ within each subperiod $I_a$ :

$$R_{Ia} = \max(X_{j,a}) - \min(X_{j,a}), \quad \text{where } j = 1, 2,..., T, \tag{7}$$

5. the sample standard deviation calculated for each subperiod $I_a$ :

$$S_{I,a} = \left(\frac{1}{T} \cdot \sum (N_{j,a} - e_a)^2\right)^{0.50}, \quad \text{for } j = 1, 2,..., T, \tag{8}$$

6.  each range $R_{Ia}$ is normalized by dividing by the $S_{Ia}$ corresponding to it. Therefore, the rescaling range for each $I_a$ subperiod is equal to $R_{Ia}/ S_{Ia}$. From step above, we had contiguous subperiods of length $T$. Therefore, the average $R/S$ value for length $T$ is defined as:

$$\left(\frac{R}{S}\right)_n = \left(\frac{1}{A}\right) \cdot \sum \left(\frac{R_{Ia}}{S_{Ia}}\right), \text{for a} = 1, 2, ..., A. \tag{9}$$

7.  The length $T$ is gradually increased to next higher value, such that *(M-1)/T* is an integer value. We use values of $T$ that include the beginning and ending points of time series, and steps 1 through 6 are reapeated until $T = (M-1)$. Then equation (3) is applied by performing an OLS regression on log*(T)* as the independent variable and $\log(R/S)_n$ as the dependent variable. Calculation was carried out by using Statgraphics. The results of calculation are in tab. 1.

**Tab. 1: Czech equity index PX50 daily return *R/S* analysis**

| *R/S* | *T* | log(*R/S*) | log(*T*) |
|---|---|---|---|
| 6.110756 | 25 | 1.81005 | 3.218876 |
| 8.664895 | 45 | 2.15928 | 3.806662 |
| 11.677419 | 65 | 2.457657 | 4.174387 |
| 15.380111 | 100 | 2.733075 | 4.60517 |
| 18.653767 | 130 | 2.926048 | 4.867534 |
| 27.298366 | 260 | 3.306827 | 5.560682 |
| 38.740518 | 450 | 3.656886 | 6.109248 |
| 50.919899 | 650 | 3.930254 | 6.476972 |
| 57.481928 | 850 | 4.051471 | 6.745236 |
| 63.494765 | 1000 | 4.150957 | 6.907755 |
| 87.545841 | 1300 | 4.472163 | 7.17012 |
| 143.9051 | 2600 | 4.969154 | 7.863267 |

Regression Analysis - Linear model: $Y = a + b \cdot X$. $\qquad$ (10)
Dependent variable: log(*R/S*)
Independent variable: log(*T*)

**Tab. 2: Regression results: Hurst exponent**

| Parameter | Estimate | Standard Error | T Statistic | P-Value |
|---|---|---|---|---|
| Intercept | -0.337269 | 0.0703581 | -4.79361 | 0.0007 |
| Slope | 0.661735 | 0.0121285 | 54.5606 | 0.0000 |

**Tab. 3: Statistical analysis: Analysis of Variance**

| Source | Sum of Squares | Df | Mean Square | F-Ratio | P-Value |
|---|---|---|---|---|---|
| Model | 10.5427 | 1 | 10.5427 | 2976.86 | 0.0000 |
| Residual | 0.0354156 | 10 | 0.00354156 | | |
| Total (Corr.) | 10.5781 | 11 | | | |
| Correlation Coefficient = 0.998325 | | | | | |
| R-squared = 99.6652 percent | | | | | |
| Standard Error of Est. = 0.059511 | | | | | |

The output shows the results of fitting a linear model to describe the relationship between $\log(R/S)$ and $\log(T)$. The equation of the fitted model is

$$\log\left(\frac{R}{S}\right) = -0.337269 + 0.661735 \cdot \log(T). \tag{10}$$

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between $\log(R/S)$ and $\log(T)$ at the 99 % confidence level.

The *R*-squared statistic indicates that the model as fitted explains 99.6652 % of the variability in $\log(R/S)$. The correlation coefficient equals 0.998325, indicating a relatively strong relationship between the variables. The standard error of the estimate shows the standard deviation of the residuals to be 0.059511.

By regression we find that the Hurst exponent for stock returns of Czech Republic is of 0.662. It corresponds with the Peters's (1991, 1994) finding for other stock market in the world. The value of Hurst exponent for PX 50 index is not far from that found for shorter time series of PX 50 by Lukáš and Plic (2003), who carried out *R/S* analysis of PX/50 index from 9/1993 to 8/1999 and value of Hurst exponent was 0.68. The fractal dimension of time series of stock returns for PX-50 calculated accordingly to formula $D = 2 - H$ then would be 1.338. It is obvious that stock returns of PX50 do not follow a random walk.

# 4. Conclusion

The Efficient Market Hypothesis which states that any new information would be immediately and fully reflected in prices and stock returns of equity or price changes would follow a random walk has long dominated theoretical investment research. But it fails to explain many observed events in daily trading experience. It ignores the liquidity trading motive, the impact of the same information on various group of traders as well as different trading horizons of investors.

The Fractal Market Hypothesis based on Fractal Market Analysis uses the self-similarity distributions and *R/S* analysis to study and describe behaviour of markets. The market is made up of many individuals with many different horizons. The behaviour of short-term trader is quite different from that of long-term investors.

Information has a different impact on different investment horizons. Short-term trades' primary activity is trading with crowd behaviour and following technical information. Long-term investors are basically interested in fundamental information and assess value of stock prices by that way. Both approaches are right for their particular investment horizons.

The stability of the market is largely matter of liquidity. Liquidity is available when the market is consisted of many investors with many different investment horizons and the traders make transactions with each other simultaneously. The market is stable because each group with different investment horizons value the information flow differently. When the market loses this structure, it becomes unstable and may lead to stampedes and crashes.

Each investment horizon is like the branching generation of a tree. The diameter of any one branch is a random function. Each investment horizon is also a random function with a finite variance, depending on the previous variance. Because the risk at each investment horizon should be equal, the shape of the frequency distribution of return is equal, once an adjustment is made for scale. The overall structure of the market has

infinite variance. The global statistical structure is fractal because it has a self-similar structure with fractal dimension ranging from 1 to 2. The shape of these distribution is high peaked and fat-tailed compared to normal distribution.

Testing the Fractal Market Hypothesis on a set of Czech equity index PX50 from September 1993 to October 2004 has led to the finding that the stock returns of Czech equity index have Hurst exponent of 0.662 or the fractal dimension of stock returns is of 1.338. It means that the price changes on Czech equity market do not follow a random walk and the market is far from being efficient.

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# Fraktální analýza trhu a její aplikace na českých podmínkách

## *Tran Van Quang*

## Abstrakt

Článek shrnuje teoretický koncept „Hypotéza Efektivního Trhu" a představuje nový koncept „Fraktální Hypotéza Akciového Trhu". Podle této hypotézy výnosy z akcií na trhu vykonávají zkreslenou náhodnou procházku, tzv. Hurstův persistentní proces, který je charakterizován svou dlouhou pamětí. Při ověření tohoto konceptu na českých indexech PX 50 byla provedena *(R/S)* analýza a byl vypočten Hurstův exponent. Ukazuje se, že výnosy z akciového indexu PX 50 vykonávají persistentní Hurstův proces s hodnotou Hurstova exponentu rovnající se 0,662. Tato hodnota je zcela odlišná od hodnoty pro náhodnou procházku a odpovídá výsledkům dosaženým v dřívějších pracích.

**Klíčová slova:** fraktální hypotéza akciového trhu; Hurstův exponent; Hurstův persistentní proces.

# The Fractal Market Analysis nad Its Application on Czech Conditions

## Abstract

This paper reviews the theoretical concept of "Effecient Market Hypothesis" and introduces new concept of "Fractal Market Hypothesis". According to this hypothesis the returns follow a biased random walk called a Hurst persistent process which is characterized as long memory process. Testing this concept on Czech stock market index PX50, the (R/S) analysis was carried out and the Hurst exponent was calculated. It finds out that stock returns of PX50 follows a persistent Hurst process with Hurst exponent of 0,662. This is significantly different from the value for a random walk and it is corresponding to results of other researches done before.

**Key words:** fractal market hypothesis; Hurst exponent; Hurst persistent process.

**JEL classification:** E 44