# TESTING THE NORMALITY ASSUMPTION ON THE ROMANIAN CAPITAL MARKET FOR GENERATING A PROPER PORTFOLIO MANAGEMENT

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## ABSTRACT

*The scientific literature, at international level, offers ample evidence that stock market is not normally distributed, this affecting classical statistical and econometric analysis in several decisive ways: correlation coefficients and the results of the t-statistic tests are giving misleading results, and, as a consequence, the case for a random walk in stock prices is seriously weakened. Testing the normality of distribution of returns on the Romanian capital market may offer important information regarding the applicability of the random walk model on the market. As a conclusion, if the market is not normally distributed, then the leptokurtosis phenomenon, attributed to a series of factors, deeply affects the classical statistical analysis, which will become useless for offering robust predictable models.*

**KEYWORDS:** *random walk, market efficiency, information, capital markets*

**JEL CLASSIFICATION:** *C50, G14, G17*

## 1. INTRODUCTION

The purpose of the article is to test the Efficient Market Hypothesis on the Romanian capital market. As the final conclusions of the previous presentation, the logical algorithm comes as following: if rates of return are not normally distributed, then the random walk theory is doubtful to be applied on the Romanian capital market.

For many years, the extend to which past history of a common stock's price can be used to make meaningful predictions concerning the future price of a stock has been a source of continuing controversions in both academic and business circles. Answers were given by chartist theories and theory regarding the random walk. The former assumes that the past behavior of a security's price provides meaningful information concerning its future behavior, as history repeats in patterns, and understanding the past behavior, one can predict the future price behavior. By the contrast, the theory of random walks says that the future path of the price level of a security is as predictable as the path of a series of cumulated random numbers. In other words, successive price changes are independent, identically distributed random variables and that the series of price changes has no memory, meaning that the past cannot be used to predict the future.

But mathematical models are, of necessity, simplifications of reality. Economies and the capital markets are particularly lacking in orderliness. By making a few simplifying assumptions about the way investors behave, an entire analytic framework has been created to help us understand the way markets evolve. Still, and as a result, the models have not worked well, their attempt was to explain some of the structure, but they leave more unanswered questions than they answer. Economists find that their forecasts, contrary to the theory, have limited empirical validity.

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## 2. IMPORTANT

Testing the normality assumption of the distribution for the Romanian capital market using BET daily closing price time series is the key point for the modelling process, and, as the random walk theory may prove doubtful, than the classical statistical theory may find itself unconvenient for the modelling process of behavior of stock market return. By the means of this article, the normality assumption has been tested, using the BET index daily closing price time series for the period between 24th of October, 2013 and 24th of October, 2014. The descriptive statistics obtained for the analyzed series suggests the rejection of the normality assumption, and this may lead to a complete different trajectory for the modelling process, meaning that the probability distribution may confirm the Mandelbrot's hypothesis, and may belong to the family of Stable Paretian Distributions.

## 3. THE FAILURE OF LINEAR PARADIGM

Before the Efficient Market Hypothesis (EMH) was fully formed, exceptions to the normality assumption were being found. One anomaly was apparent when Osborne (1964) plotted the density function of stock market returns, and labeled the returns "approximately normal": he noted that there were extra observations in the tails of the distribution, and this phenomenon is called by statisticians as "kurtosis". This phenomenon, in the literature and for the academic world, had no significance, turning into the fact that it was generally accepted that the distribution of price changes had fat tails.

Fama (1965a) performed the first complete study on daily returns, and proved that the returns were negatively skewed, meaning that there were more observations in the left-hand (negative)tail than in the right-hand tail. Another observation regarding the empirical distribution conducted to the conclusion that the tails were fatter than predicted, and the peak around the mean was higher than predicted. In his study published in 1965, "The behavior of stock market prices", in order to present his conclusions regarding the usefulness of the normality assumption on the capital market, Fama conducted his study beginning from the underlying theory of the random walk in stock prices. As a general rule, the theory of random walks in stock prices is based on two hypotheses: (1) successive price changes in an individual security are independent, and (2) the price changes conform to some probability distribution. Comparing the two hypothesis, the independence hypothesis is the most important, without it there will be no random walk. The second hypothesis refers to the fact successive price changes conform to some probability distribution that characterizes the process generating the price change. From the statistic point of view, the form of the distribution is a major factor in determining the riskiness of investment in common stocks, offering relevant descriptive information about the nature of the process generating price changes. Normally, a probability distribution is characterized by different variables, among which we could mention mean and variance, and if the distribution has a high degree of dispersion, the explanation may be due to the variability of the process generating new information.

The first complete development of the random walk theory was due to Bachelier, at the beginning of the last century, and continued by Osborne fifty years later. The Bachelier-Osbourne model respects some important assumptions, namely: price changes from transaction to transaction in an individual security are independent, identically distributed random variables, transactions are fairly uniformly spread across time, and the distribution of price changes has finite variance. In the case of a large number of transactions, and under the conditions of the Central Limit Theorem, then the daily, weekly, monthly price changes will have normal or Gaussian distributions. Moreover, the variances of the distribution will be proportional to the respective time intervals. In this respect, if

$\sigma^2$ is the variance of the distribution of daily price changes, then $5\sigma^2$ is the variance of the distribution of weekly price changes.

Regarding the normality assumption, Kendall (1964) noticed that weekly price changes in British common stocks were normally distributed, and in this respect, he labeled them as "approximately normal", as they were leptokurtic. The same conclusion was reached also by Sharpe (1963), when he compared annual returns to the normal distribution, and this may lead to a very important difference between normal and leptokurtic distributions: normal distribution assigns little likelihood to the occurrence of really extreme events, but in real world, such events occur quite often. On the other hand, leptokurtic distribution refers to distributions that have too many values near the mean and too many out in the extreme tails. Sterge (1989), in his study regarding financial futures prices of Treasury Bond, Treasury Note and Eurodollar contracts, identifies the same leptokurtic distributions, and from the calculus, he deducted that very large price changes can be expected to occur two or three times as often as predicted by the normality. All those studies provide enough evidence that stock market returns are not normally distributed.

All the scientific literature, at international level, offer ample evidence that stock market returns are not normally distributed, and this attracts other series reactions, like: statistical analysis, particularly correlation coefficients and t-statistics, is seriously weakened and may give misleading answers. The case for a random walk in stock prices is seriously weakened.

If stock returns are not normally distributed, then much statistical analysis, particularly the Gaussian hypothesis was not seriously questioned until the work of Benoit Mandelbrot (1960, 1964) appeared. His main assertion was the fact that the academic research really neglected the implications of the leptokurtosis usually observed in empirical distributions of price changes, which are indisputable. The classic approach to this problem has been to assume that the extreme values are generated by a different price mechanisms than the majority of the observations. As a result, one tries a posteriori to find "causal" explanations for the large observations, and thus to rationalize their exclusion from any tests carried out on the body of the data. The technique used for the exclusion of the extreme values from the sample is called "trimming". Mandelbrot's intuition conducted him to the idea that excluding extreme values from the sample takes away much of the significance from any tests carried out on the remainder of the data. Mandelbrot criticizes the exclusion process because of the assimilation of the probability distribution to normal or Gaussian, as long as there are available precise group of distributions, which he labeled as stable Paretian. Those specific and particular family of distributions have certain characteristics, due to the fact that there are four parameters involved into their descriptive statistics. Mandelbrot's hypothesis states that for distributions of price changes in speculative series, they have specific means, but their variances are infinite. Stable Paretian distributions are characterized by a tendency to have trends and cycles, as well as abrupt and discontinuous changes, which can be adjusted for skewness. Variance for those family of distributions is infinite, or undefined. As a reaction to Mandelbrot's work, Cootner (1964b), Miller(1990) and Shiller (1989) preferred to reformulate the existing theory in terms of normal distributions, rather than face the possibility that the past 40 years of economic and capital market research may be seriously flawed. Cootner (1964a), criticizing Mandelbrot, proved that one is not sure that measuring the tails of the distribution, the distribution is not a leptokurtic Gaussian distribution. He concluded, disillusioned, that if Mandelbrot were right, than "almost all of our statistical tools are obsolete", and he felt that there were needed more proof before accepting this scientific proof (Peters, 1991).

As a consequence, the simplifying assumption of a rational investor concept and the Efficient Market Hypothesis were constructed to justify the use of probability calculus by giving an economic framework to the crucial assumption of independence of observations of returns. Capital market theory aimed to make the investment environment neater, or more orderly, than it is in reality. The factors that are disturbing the classical approach of the capital markets are namely:

1. People are not necessarily risk-averse all the time, meaning that sometimes they can be risk-seeking, especially in situations when they have to decide between sure losses and gambling (Tversky).
2. People are not unbiased when they set subjective probabilities, meaning that they are to be more confident in their forecasts than in the information they perceive.
3. People may not react to information as it is received. They may react later to the information, if it confirms a change in a recent trend. This is a nonlinear reaction, opposed to the linear reaction predicted by the rational investor concept.
4. At a practical level, there is no evidence to support the belief that people in aggregate are more rational than individuals. For proof, one only has to look at the social upheavals, fads, and fashions that have occurred throughout human history.

Econometric analysis was desirable because it could be solved for optimal solutions. But, if markets are nonlinear, there are many possible solutions, thus the attempt to find a single optimal solution can misguide the scientific research.

## 4. ROMANIAN CAPITAL MARKET – TESTING THE NORMALITY OF THE DISTRIBUTION

The purpose of the paper is now to test the efficient market hypothesis on the Romanian capital market. As the final conclusions of the previous presentation, the logical algorithm comes as following: if rates of return are not normally distributed, then the random walk theory is doubtful to be applied on the Romanian capital market.

Efficient market hypothesis has been previously tested on the Romanian capital market. Pele, one of the Romanian authors that studied the implications of the efficient market hypothesis on the capital market, remarks the fact that Osbourne, in a published paper in 1959 regarding the appliance of the Brownian motion over the capital markets, makes proof of the fact that, for increasing accuracy of the forecasts, one should make use of the logarithmic price of the asset, and not the normal price, due to the fact that the logarithmic price series usually can derive from a normal distribution, fact whose utility can be easily understood in the modelling process. In the same paper, Osbourne mentions the "square root of time rule", derived as follows: if we note by

$$Y(\tau) = \ln\left(\frac{P(t+\tau)}{P(t)}\right) \qquad (1)$$

the successive price change for the time interval $(t, t+\tau)$, then $Y(\tau) \approx N(0, \sigma^2_{Y(\tau)})$, where standard deviation $\sigma_{Y(\tau)}$ increases directly with the square root of time interval $\sigma_{Y(\tau)} = \sigma_t \sqrt{\tau}$, where $\sigma_t$ is the standard deviation for the moment t.

For the case of emerging capital markets, as from the east European ex-Communist countries, due to some particularities of those markets, as lack of liquidity, econometric tests may be distorted. (Pele and Voineagu, 2008). Informational efficiency of the Romanian capital market has been widely tested for the last years. From this point of view, most of the studies have been correlated with the possibility of obtaining abnormal profits. (Dragota, Caruntu, Stoian, 2006).

As a consequence, the statistical manner to express the market efficiency is the random walk hypothesis, that can be formulated under three sub-hypotheses: independent and identically distributed increments, independent increments, uncorrelated increments.

For an in-depth understanding of the manner the random walk theory applies on the Romanian capital market, we will use the closing daily price time series of the BET index, for the period between 24th of October, 2013, and 24th of October, 2014. Some theoretical aspects regarding the random walk theory must be mentioned, also. In this manner, a time series can be considered as following a random walk process if:

$$x_t = \alpha + x_{t-1} + \varepsilon_t , \qquad (2)$$

where $\varepsilon_t$ represents a random stationary series.

The random walk series ($x_t$) has an estimated value, respectively its mean, and its variance increases with time and is stationary when the first difference is stationary. The last expression can be written as:

$$x_t - x_{t-1} = \varepsilon_t . \qquad (3)$$

In this way, analysing the series' stationarity represents one of the major objectives in testing the random walk model. Testing the random walk hypothesis of the financial assets time series represents a primordial objective of the investors, analysts and capital market teoreticians. Rejecting this hypothesis equivalates the fact that security titles do not follow a random walk model, due to the random process of introducing new information. Basically, this can be translated into functional predictible models, meaning that the possibility of existing investors or groups of investors capable of obtaining „abnormal profits" or „to beat the market" can be turned real, due to obtaining rates of return superior to market return. Another definition given to stationarity can be considered the following: a random variable that follows a stable probability distribution during time represents a stationary process. If the probability distribution supports changes during time, in other words, its mean and variance change during time, then the process is non-stationary.

In order to test different aspects regarding the behavior of Romanian capital market, there were used daily values for BET index, for the period 24th of October, 2013, and 24th of October, 2014. Based on these data, there were computed daily returns, using the closing price of index for every trading day, using the formula $r_t = ln\frac{P_t}{P_{t-1}}$, where $P_t$ represents the closing price of the index BET for day t.

**Analysis of the normality of the distribution for the values of the BET index**

The most frequently used instrument is the histogram. In our case, the distribution obtained by histogram for the closing daily returns for the BET index is presented below:

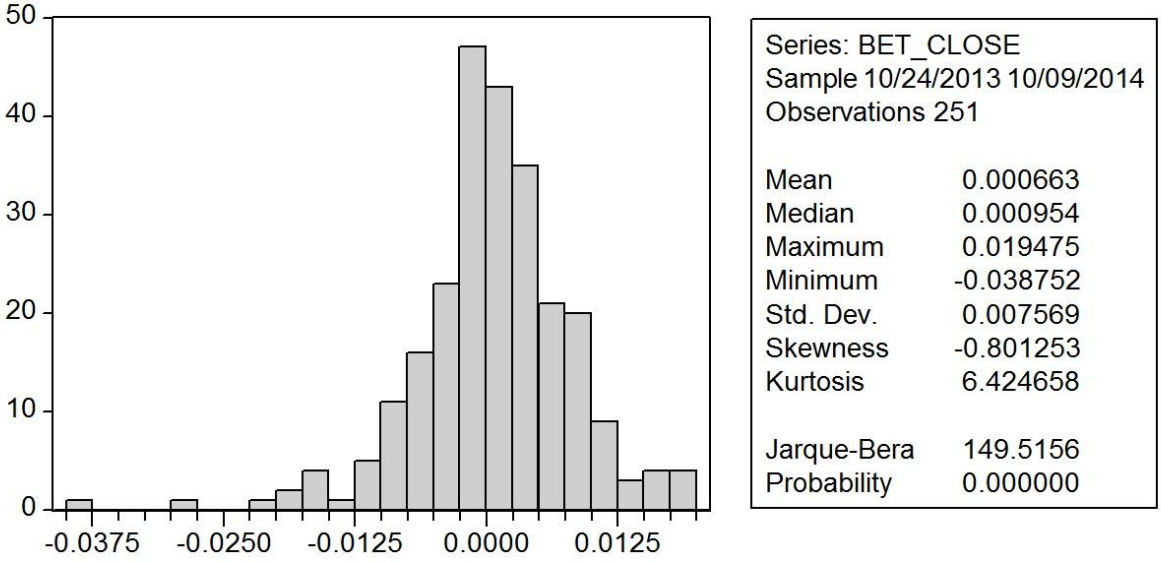


**Figure 1. Descriptive statistics and normality test for daily returns on BET index**

Analysing the indicators of the distribution of the daily returns, some conclusions can be drawn:

- in all the cases, the hypothesis of normal distribution cannot be accepted, fact revealed both by the values of kurtosis, skewness and Jarque-Berra statistics.
- the distribution of the returns is leptokurtic, the shape being different from the normal distribution.

The value of the skewness indicator is S= -0.801253 (the skewness of the distribution of returns of the BET index is negative), meaning that the distribution is left tail skewed, with a value that is pretty high, and the skewness is easily noticed. This means, based on empirical data, that the series of return is not normally distributed.

The value of the kurtosis indicator is K=6.424658, meaning that the distribution is leptokurtic, its hight being bigger than in the case of normal distribution.

The value of the Jarque-Berra test indicates if a time series is normally distributed or not. In our case, the probability value equals zero, meaning the rejection of the null hypothesis, that assumes that the series is normally distributed, meaning that the time series of the closing daily BET index returns is not normally distributed.

## 5. CONCLUSIONS

As a conclusion, the normality assumption of the Romanian capital market is not fulfilled, meaning that the statistical classical analysis, correlation coefficient and T-statistics give misleading results. Based on these, these conclusion may offer an ample possibility for using further dynamic models for generating, reconstructing and understanding the behavior of the security prices, using other distribution probabilities that reflect in a proper manner the market processes.

## ACKNOWLEDGEMENT

This paper has been financially supported within the project entitled "*Routes of academic excellence in doctoral and post-doctoral research*, contract number *POSDRU/159/1.5/S/137926*, beneficiary: Romanian Academy, the project being co-financed by European Social Fund through Sectoral Operational Programme for Human Resources Development 2007-2013.

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