ROMANIAN CAPITAL MARKET: RANDOM WALK OR WEAK FORM OF INEFFICIENCY?

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Abstract
A continuous and ongoing effort for the investment and academic area represents the possibility of shaping the financial assets's behavior for obtaining forecasts with a high degree of accuracy with respect to the future rates of return. The goal of this paper is to consider forecasting the fluctuations of the security titles, starting from the hypothesis that those are influenced by past values; of course, this is not a complete approach, as in every moment the amount of data that an investor may possess is much richer than the amount of historical rates of return, but it represents a starting point for modeling the behavior of financial assets. The first condition that should be verified regarding Romanian capital market is weak-form market efficiency.

Keywords: random walk, market efficiency, information, capital markets.

1. INTRODUCTION

In 1827 an English botanist, Robert Brown, noticed that small particles suspended in fluids perform peculiarly erratic movements. This phenomenon, which could also be attributed to gases, is referred to as Brownian motion. After that moment further, the theory has been considerably generalized and extended by Fokker, Planck, Burger, Ornstein, Uhlenbeck, Chandrasekhar, Kramers and others. On the purely mathematical side, various aspects of the theory were analyzed by Wiener, Kolmogoroff, Feller, Levy, Doob (1939) and Fortet (1943). Even Albert Einstein had an important contribution to this theory.

The limitations of this theory were already recognized by Einstein and Smoluchowski (1916), but are often disregarded by other writers. An improved theory, known as „exact", was advanced by Uhlenbeck and Ornstein (the Ornstein-Uhlenbeck Process) (1930) and by Kramers (1946). The random walk theory was first brought to light by the discrete approach of Einstein-Smoluchowski, and it consists in treating Brownian motion as a discrete random walk. The main advantages of this discrete approach are pedagogical, but it may suggest various generalizations which will contribute to the development of the Calculus of Probability.

The random walk theory has nowadays a practical implication into the financial theory, stating that the stock prices evolve accordingly to a random walk, and thus they are impossible to predict. This theory is

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consistent with the efficient-market hypothesis. In finance, this theory is mainly linked by the name of Eugene Fama (1965), even if Burton Malkiel (1973) is considered to have strongly developed it.

The study was conducting by starting with reviewing the literature regarding the Brownian motion, Wiener process, Ito process, Ornstein-Uhlenbeck process and reaching the random walk theory. Starting from the major theories, the random walk theory is presented under its major sub-hypothesis, starting from independent and identically distributed increments and reaching to dependent increments, but uncorrelated. In order to apply those hypotheses, there was used time series extracted from the daily closing prices for the BET Index, for the period starting from the 22th of September, 1997, and ending to the 10th of July, 2015. The descriptive statistic of the time series is obtained, and the Augmented Dickey Fuller Test is applied, in order to determine the application and the compliance of this theory with the Romanian Stock Market.

2. RANDOM WALK THEORY – MAJOR SUB-HYPOTHESIS IMPORTANT

Basically, a market is defined to be information – efficient if no investors can reach abnormal systematic earnings and, also, the true expected return of any security is equal to its equilibrium expected value (Fama, 1976). From the first point of view, the main concern for the market is to give equal chances to each investor, which means that there are no investors able to gain every time and investors to lose every time. From the second opinion, it is important for markets to work, thing that will have as a result a right estimation of asset returns. In this context, there were many trials to develop instruments for testing market information efficiency. Many investigation techniques used in order to test the possibility of earning abnormal returns were revealed. In this sense, Kendall (1956) and Alexander (1961) turned to tests of the serial correlation; Fama and Blume (1966) appealed to simple trading rules tests; Jagadeesh (1990) and Jagadeesh and Titman (1993) resorted to overreaction tests; DeBondt and Thaler (1985), Poterba and Summers (1998) and Fama and French (1988) fell back upon tests of long-horizon return predictability.

Campbell, Lo and MacKinley (1997) stated that „any test of efficiency must assume an equilibrium model that defines normal security returns. If efficient hypothesis is rejected, this can be because the market is truly inefficient or because an incorrect equilibrium model has been assumed”.

Fama (1970) stated that a market is information efficient if prices fully reflect all the available information from the market.

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The notion of market efficiency can be as follows: the more efficient the market is, the more aleatory the sequence of price changes generated by the market is (Dragota, Stoian, Pele, Mitrica, Bensafta, 2009).

At least with the emerging markets, such as East European Ex-communist Countries, due to some of their particular features, such as lack of liquidity, econometric tests could be distorted (Pele and Voineagu, 2008). The informational efficiency of the Romanian capital market was differently tested in the past years. From this point of view, most of the studies were related to the possibility of gaining abnormal earnings (Dragota, Caruntu, Stoian, 2006).

Similar studies were done for other ex-communist countries. For instance, Chun (2000) based on variance ratio tests found that the Hungarian capital market was weakly efficient; Gilmore and McManus (2003) investigated informational efficiency in its weak form from the Czech Republic, Poland and Hungary (within 1995-2000) and rejected the random walk hypothesis based on the results of a model comparison approach.

Consequently, the statistical manner to express the market efficiency is the random walk hypothesis (RWH), which can be formulated in three different sub-hypothesis, respectively: independently and identically distributed increments, independent increments, uncorrelated increments. Those sub-hypothesis starts from a less broad perspective, getting to a more relaxed and natural perspective. Those hypotheses are further presented:

3. RW1 HYPOTHESIS: INDEPENDENT INCREMENTS, IDENTICALLY DISTRIBUTED INFORMATION

The most natural way of expressing the random walk hypothesis is the one in which the price of financial assets is represented by a stochastic process, following an internal dependency of the manner:

$$P_t = \mu + P_{t-1} + \varepsilon_t \qquad (1)$$

where $\varepsilon_t \sim WN(0, \sigma^2)$ represents a white noise, a series of independent random variables, identically distributed: $E[\varepsilon_t] = 0, \forall t$, $Var[\varepsilon_t] = \sigma^2, \forall t$, $\varepsilon_t \; si \; \varepsilon_{t+k} \; independent \; variables, \forall k \neq 0$. More, $cov[\varepsilon_t, \varepsilon_{t+k}] = 0$ and $cov[\varepsilon_t^2, \varepsilon_{t+k}^2] = 0, \forall k \neq 0$.

In equation (1), P_t, P_{t-1} represent the price values for two succesive time moments, and μ represents the expected price movement, the so-called drift.

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The most common condition for the random variable ε_t is the fact it follows a normal distribution function, except the fact that it represents a white noise, condition that generates a certain formal commonness. But this may be the cause of appearing certain irregularities with the practice, due to the fact that the normal distribution function covers the whole range of real numbers, and it may result into the fact that there may be a non-zero probability that the price of a security title to be negative. A way of avoiding this fact may be by using instead of stock prices series, the series of natural logarithms of those prices: $p_t = \log P_t$.

Model RW becomes then a log-normal model:

$$p_t = \mu + p_{t-1} + \varepsilon_t \qquad (2)$$

where $\varepsilon_t \sim WN(0,\sigma^2)$ represents a white noise.

4. RW2 HYPOTHESIS: INDEPENDENT INCREMENTS

Even the simplicity and the elegance of the RW1 Model seem very alluring, the supposition of the existence of identically distributed independent increments is not quite natural.

The influencing factors that determine the evolution of the prices of financial assets are not always the same and do not affect those prices with the same intensity. Also, the economic conditions vary much during time, this making the hypothesis of the existence of the same distribution function over time to be not natural.

Then, the RW2 model derives directly from the RW1 model, but the single difference resides in ignoring the hypothesis of the same distribution function of the random variable ε_t:

$$P_t = \mu + P_{t-1} + \varepsilon_t \qquad (3)$$

where: ε_t is a series of random variables: $E[\varepsilon_t] = 0$, $Var[\varepsilon_t] = \sigma_t^2, \forall t$, $cov[\varepsilon_t, \varepsilon_{t+k}] = 0$ and $cov[\varepsilon_t^2, \varepsilon_{t+k}^2] = 0, \forall k \neq 0$.

Even RW2 model is weaker than the RW1 model, the former keeps the essence of the latter: every future movement of the stock prices is unpredictable, using the past price movements.

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5. RW3 HYPOTHESIS: UNCORRELATED INCREMENTS

Relaxing the hypothesis of the above-described models, we can obtain a more generalized form of the random walk hypothesis, in which increments are dependent, but uncorrelated.

$$P_t = \mu + P_{t-1} + \varepsilon_t \text{;} \qquad (4)$$

where ε_t is a series of random variables, $E[\varepsilon_t] = 0, \forall t$, $Var[\varepsilon_t] = \sigma_t^2, \forall t$ and $cov[\varepsilon_t, \varepsilon_{t+k}] = 0$.

6. TESTING THE WEAK FORM EFFICIENCY ON THE ROMANIAN CAPITAL MARKET

In order to test the weak-form efficiency of the Romanian capital market and different aspects regarding the behavior of financial assets, we have used daily closing prices for the BET Index, for the period starting from the 22th of September, 1997, and ending to the 10th of July, 2015. Based on those data, we have computed the daily rates of return, using the daily closing prices, by the formula: $r_t = ln\frac{P_t}{P_{t-1}}$, where P_t represents the daily closing price of day t.

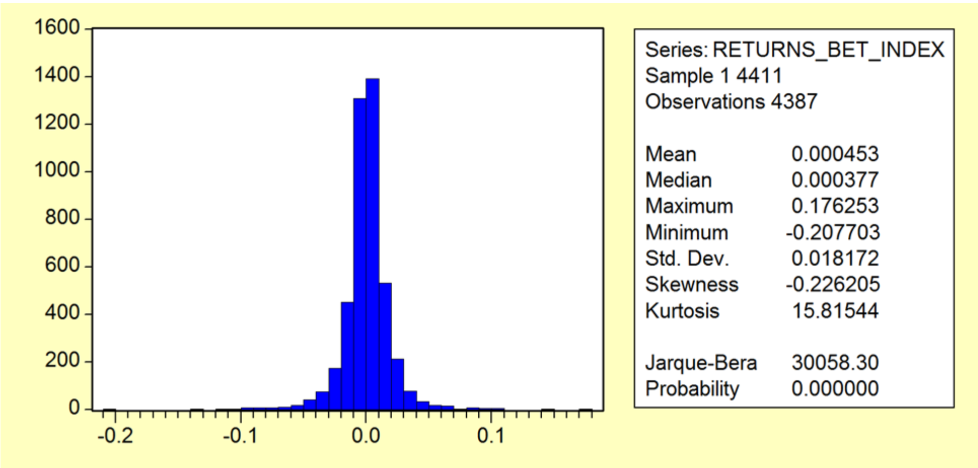

FIGURE 1 - DESCRIPTIVE STATISTICS AND VERIFYING THE NORMAL DISTRIBUTION OF THE DAILY RATES OF RETURN

Analyzing 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.

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The value of the skewness indicator is S= -0.226205 (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 small, and the skewness is not so 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=15.8154, meaning that the distribution is leptokurtic, its hight being much 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.

For testing the Efficient Market Hypothesis in its weak form, further there will be used a statistical test used to study the random evolution of a time series: the Augmented Dickey-Fuller (ADF) test. This statistical test offers probabilities to the accepted hypotheses, and generic can be also called “unit root test”. The absence of a random walk for a time series is equivalent to the fact that there is no chaotic movement within markets, so, there may be possible price forecasting through the modeling process. The Augmented Dickey-Fuller (ADF) test’s assumption is that the rates of return time series follows an Autoregressive stochastic process, AR(1).

Null Hypothesis: RETURNS_BET_INDEX has a unit root

Exogenous: Constant, Linear Trend

Lag Length: 0 (Automatic based on SIC, MAXLAG=30)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-60.09683	0.0000
Test critical values:	1% level	-3.960142	
	5% level	-3.410835	
	10% level	-3.127216	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(RETURNS_BET_INDEX)

Method: Least Squares

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Date: 07/28/15 Time: 20:12
Sample (adjusted): 2 4411
Included observations: 4362 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RETURNS_BET_INDEX(-1)	-0.900698	0.014987	-60.09683	0.0000
C	0.000370	0.000545	0.678230	0.4977
@TREND(1)	-1.48E-09	2.13E-07	-0.006918	0.9945

R-squared	0.453118	Mean dependent var	-2.44E-05
Adjusted R-squared	0.452867	S.D. dependent var	0.024327
S.E. of regression	0.017994	Akaike info criterion	-5.196824
Sum squared resid	1.411439	Schwarz criterion	-5.192435
Log likelihood	11337.27	F-statistic	1805.818
Durbin-Watson stat	2.009284	Prob(F-statistic)	0.000000

FIGURE 2 - TESTING THE STATIONARITY OF THE DAILY RATES OF RETURN FOR THE BET INDEX CLOSING VALUES, USING THE ADF TEST

7. CONCLUSIONS

As it can be noticed from the test results, value of the test is inferior to the critical values, for every significance level: 1%, 5%, 10%. As a result, the null hypothesis according to which the rates of return of the BET Index time series has a unit root is rejected.

This means that the series is stationary and does not follow a random walk process, and the Romanian market presents a weak form of inefficiency.

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