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Testing weak form informational efficiency on the Romanian capital market

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Abstract. *The informational efficiency of the Romanian capital market was previously studied, by different approaches. The first condition that needs verification is that of weak form informational efficiency. The present paper aims to make contributions in this direction, namely to test weak form efficiency, on a sample composed of recent data, collected from the most liquid companies listed on our country's capital market. For this approach, we use the unit root tests. The results are useful to potential investors, interested to find out whether they can or cannot obtain excessive earnings, by studying stock prices history.*

Keywords: capital market; stock price; weak informational efficiency; unit root tests; excessive earnings.

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The objective of this study

The purpose of this study is to determine whether the Romanian capital market is characterized by the weak form of informational efficiency. Specifically, the research is conducted on the Bucharest Stock Exchange, the organized market for security trading. This approach is not unprecedented, because since the rebirth of the Romanian stock market in 1995 and until the present day a lot of similar analyses have been carried out. However, the results of these studies are closely related to a specific moment in time, i.e. the context in which they appeared. Because the Romanian capital market had evolved rapidly over the past years, it is logical to assume, at first sight, that also the level of informational efficiency that characterizes the market has been altered.

Considering that, on a market characterized by the weak form of informational efficiency, an investor cannot obtain excessive earnings by trading based on stock prices history, the conclusion of this research will also imply a specific aspect regarding the pragmatism of securities portfolio management. Thus, depending on the investor's behavior regarding risk, a risk-loving investor could think that on an informationally inefficient market he will be able to speculate and win more, while a risk-averse investor will value more an informationally efficient market, where his revenues are moderate and where he can minimize his portfolio risk.

Literature review

There are three fundamental forms of informational efficiency of the market, according to Eugene Fama's taxonomy: the weak form, the semi-strong form and the strong form (Fama, 1965, pp. 34-105).

The weak form of informational efficiency is defined by the situation in which, on the capital market, the prices of the assets reflect all their past history, fully and instantaneously: the market prices from the past, the variation in the prices, the volume of the transactions etc. Thus, there will be no correlations between the past changes and the future changes of the stock prices; the prices' variations are independent. This also implies that it is not possible to obtain excessive earnings by trading based on studying the assets' prices history.

Previous studies in this area show that the Romanian capital market lacks the weak form of informational efficiency. This means that it also lacks the other two levels of informational efficiency: the semi-strong and strong form.

For example, Dragotă and Mitrică, by using the standard econometric testing methodology, concluded for the absence of weak efficiency; the Romanian capital market does not fulfill the conditions required for the weak

form of informational efficiency. In these conditions, testing the other forms of informational efficiency was no longer necessary. However, the study shows that transaction costs and temporary lacks of market liquidity do not allow the earning of excessive returns (Dragotă, Mitrică, 2004, pp. 353-360).

For testing the hypothesis of informational efficiency in its weak form, Todea used a sample of 10 companies listed at the Bucharest Stock Exchange, at the first tier (Todea, 2002). These companies had been or are, at the present time, part of the BET index basket. The study period is between the years 1997 and 2000, comprising a sample of over 800 observations. For eight stocks, the analysis confirmed the possibility of stochastic modeling and prediction. But predictions are not useful to the analyst in order to obtain systematic earnings because all investors will have the same anticipations, if the information available to them is limited to past stock prices and returns.

The weak form of market informational efficiency can be described through different mathematical models. Such a model is the "random walk" model. The model assumes random evolution for the stock prices series.

The model's fundamentals were established by Louis Bachelier, the first scientist who used statistical analysis for studying stock prices (Bachelier, 1900). Subsequently, Maurice Kendall analyzed the time series generated by stock prices evolution and came to the conclusion that they follow a "random walk" (Kendall, 1953, pp. 11-25).

The model, formulated and tested effectively by Eugene Fama and Merton Miller, includes two major hypotheses (Fama, Miller, 1972):

- stock prices fully and instantaneously reflect the information available regarding the traded stock; therefore, the prices' successive variations are independent, and the same thing applies to returns;
- variations of prices are identically distributed.

According to this model, the reflection of all available information within the stock price, explained by the prices' successive variations independence, can be mathematically transcribed in the following manner:

$$P_t = \rho \times P_{t-1} + \varepsilon_t$$

The notation system is as follows: P = stock price; t, t -1 = two successive moments on the time axis; $\rho = 1$; ε_t = regression error.

P_t is a time series and ε_t is a random series. For a valid regression, the error ε_t will describe a "white noise" type of stochastic process, cumulatively fulfilling the following requirements: a normal distribution with mean equal to 0, not autocorrelated and homoscedastic (its variance is constant).

Analysis methodology

In order to test weak form informational efficiency, we use two tests designed for studying the random evolution of a temporal series: the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron test. These tests provide probabilities for the accepted hypotheses and are generically called "unit root tests".

The absence of a "random walk" type of evolution implies the existence of the possibility of modeling the stock prices series' trajectory. In this situation, there will be possible to obtain excessive, abnormal earnings, by analyzing the past which reproduces itself into the future. Thus, the stock market on which these prices are met is informationally inefficient in the weak form.

The *Augmented Dickey-Fuller (ADF)* test is based on the assumption that the series of natural logarithms of daily stock prices follow an AR (1) type of stochastic process, order 1 autoregressive. Optionally, a trend component can be added, which is a function of time (φ t), designed to indicate the general trend of the series' evolution (Dragotă et al., 2003, p. 121):

$$\ln(P_t) = \mu + \varphi t + \rho \times \ln(P_{t-1}) + \varepsilon_t$$

We will utilize a modified formula of this stochastic process, in which $\gamma = 1 - \rho$:

$$\Delta\ln(P_t) = \mu + \varphi t + \gamma \times \ln(P_{t-1}) + \varepsilon_t$$

The unsimplified form of the tested equation also includes the differences of the series past values, together with their coefficients. The number of differences included is optional.

Then, we will test the null hypothesis, that the series has a "unit root":

$$H_0 \rightarrow \gamma = 0 \Rightarrow \rho = 1$$

The procedure consists of a t-statistic test applied on the γ coefficient. The results of the test will be compared with the critical values provided for different significance levels.

If the test result is superior to the critical values, for significance levels of 1%, 5% and 10%, then the null hypothesis of unit root presence within the daily stock prices series, cannot be rejected (Dragotă et al., 2003, p. 122). Thus, the analyzed series is not stationary and it may follow a "random walk".

Therefore, if the result of the t-statistic test is superior to the critical values, then, most likely, the series has a unit root and, consequently, it is possible for the capital market, on which the prices had been recorded, to be informationally efficient in weak form.

The *Phillips-Perron* test is an alternative test to the ADF test, which does not include in the tested equation the differences between the series past values

and which uses simple ordinary least squares for estimating the equation. As in the case of the ADF test, the null hypothesis $\rho = 1$, of unit root presence, is tested. In essence, this test is a t-statistic for the regression coefficient, but adjusted in order to remove certain errors.

The obtained result is compared, same as in the case of the ADF test, to the critical values provided for significance levels of 1%, 5%, and 10%. The interpretation is identical with the one from the Augmented Dickey-Fuller test: a test result superior to the critical values, for all significance levels, indicates, most likely, the unit root presence and, consequently, it is possible for the market to be informationally efficient in the weak form.

We emphasize that, a result superior to critical values, for both tests, shows only a high probability for the presence of weak informational efficiency. We will not be able to draw definitive conclusions, in this direction.

Specifically, the two tests described above are applied on the series of natural logarithms of daily stock prices.

Data base

The sample under analysis contains the daily stock prices of the 10 most liquid companies listed on the regulated market of the Bucharest Stock Exchange (BSE). Using these companies' prices, the reference index of the Romanian capital market, namely the BET index, is computed. Therefore, this sample adequately represents the main investment opportunities on the Romanian capital market. On this basis, the study's conclusions will be extrapolated to the entire market on which the representative stocks are traded (Dragotă et al., 2003, p. 121).

The previously described statistical tests are preformed for each stock, part of the BET index basket. Afterwards, we will take note of which stocks fulfill the minimum requirement of weak form informational efficiency, namely the existence of a unit root.

An important observation at this point is as follows: for the market to be weak form efficient, all the analyzed stocks must "pass the tests". It is sufficient for only one stock not to fulfill the mentioned requirement in order to conclude that the entire market, on which this stock is listed, is not efficient.

The symbols of the companies from the BET composition are the following: SNP, BRD, FP, TLV, TGN, TEL, BIO, BVB, AZO and BRK. The names of these companies are available on the BSE website (www.bvb.ro – indices and indicators).

For each one of these listed companies, we collected the daily stock price from the www.kmarket.ro website. Thus, in a first phase, we obtained a

chronological series composed of two variables: date (trading day) and stock price (closing price). All of this information is publicly available on the internet (www.kmarket.ro).

However, in the actual data analysis, we will use the natural logarithms of stock prices. Thus, in a second phase, we calculated the natural logarithm. The latter defines a third variable of the chronological series: logarithm (natural logarithm).

The data base has, therefore, the following generic structure:

Date	Price	Logarithm
……..	……..	……..
……..	……..	……..

Figure 1. *The generic structure of the database*

The number of recorded values (observations on variables) is consistent with obtaining statistically significant results. The previously mentioned digital resource allows for collecting the entire market trading history, of the analyzed stocks.

Numerical results of empirical analysis

For the Romanian market to be informationally efficient in the weak form, the empirical results must justify the impossibility of gaining excessive earnings by studying the historical series of daily stock prices. Therefore, if it will be proven that excessive returns may be obtained for the case of a single stock, then the capital market is informationally inefficient. The existence of a single "breach" regarding stock price predictability is sufficient to affirm, with certainty, that the weak form informational efficiency hypothesis is not valid.

Below are presented the detailed results of the two tests performed for a single stock from the sample, namely the case of BIO.

The results of the *Augmented Dickey-Fuller (ADF)* test are the following:

Table 1

The results of applying the ADF test, for the case of BIO

Null Hypothesis: D(LOGARITHM) has a unit root				
Exogenous: Constant				
Lag Length: 4 (Fixed)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-16.21791	0.0000
Test critical values:	1% level		-3.434689	
	5% level		-2.863344	
	10% level		-2.567779	

Source: own processing.

As can be observed, the test value is inferior to the critical values, for any significance level: 1%, 5% and 10%. Therefore, the test rejects the null hypothesis which states that the stock prices' series of natural logarithms has a unit root. This indicates that the series is stationary and does not follow a "random walk" type of stochastic process, thus the market on which the prices had been recorded is informationally inefficient in the weak form.

The results of the *Phillips-Perron* test are included in the following table:

Table 2

The results of applying the Phillips-Perron test, for the case of BIO

Null Hypothesis: D(LOGARITHM) has a unit root				
Exogenous: Constant				
Bandwidth: 6 (Fixed using Bartlett kernel)				
			Adj. t-Stat	Prob.*
Phillips-Perron test statistic			-35.15009	0.0000
Test critical values:	1% level		-3.434677	
	5% level		-2.863338	
	10% level		-2.567776	

Source: own processing.

The interpretation is identical with that of the ADF test: the test's value is inferior to the critical values, for all levels of significance. This indicates that the series has no unit root, thus the market on which the BIO stocks are traded is not efficient in the weak form.

The systematized results of the two tests, for all 10 analyzed stocks, are annexed to the present paper (Annex – The results of the unit root tests).

As can be observed, for the case of both unit root tests, Augmented Dickey-Fuller and Phillips-Perron, and for all stocks under analysis, the test result is inferior to the critical values, for significance levels of 1%, 5% and 10%.

Consequently, we reject the null hypothesis, according to which the prices' series of natural logarithms has a unit root. This implies that the series is stationary and does not follow a "random walk" process. Thus, the market on which these stocks are listed is not informationally efficient in the weak form.

Conclusions

According to the results obtained by performing the unit root tests, on a sample comprised of the most liquid companies listed on the Bucharest Stock Exchange, we reject the null hypothesis of unit root presence within the series of the analyzed stock prices. Thus, the studied series do not evolve accordingly with the "random walk" model.

To conclude, whereas the indispensable condition of stock prices random evolution is not met for any of the analyzed stocks, we can affirm, without a doubt, that the Romanian capital market is not characterized by the weak form of informational efficiency. Theoretically, excessive gains may be earned by trading based on studying historical prices.

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Annex

The results of the unit root tests

Stock	ADF	1% Critical Value	5% Critical Value	10% Critical Value
SNP	-22.52475	-3.432863	-2.862536	-2.567346
BRD	-22.27350	-3.432696	-2.862462	-2.567306
FP	-6.861323	-3.463405	-2.875972	-2.574541
TLV	-25.91861	-3.432138	-2.862215	-2.567173
TGN	-14.30660	-2.567443	-1.941163	-1.616471
TEL	-16.54648	-3.435283	-2.863606	-2.567920
BIO	-16.21791	-3.434689	-2.863344	-2.567779
BVB	-8.952567	-3.448518	-2.869442	-2.571047
AZO	-24.62546	-3.432005	-2.862157	-2.567142
BRK	-18.15103	-3.434234	-2.863143	-2.567671
Stock	**Phillips-Perron**	**1% Critical Value**	**5% Critical Value**	**10% Critical Value**
SNP	-44.82528	-3.432859	-2.862534	-2.567345
BRD	-46.95439	-3.432692	-2.862461	-2.567305
FP	-12.48348	-3.462737	-2.875680	-2.574385
TLV	-56.74779	-3.432136	-2.862214	-2.567173
TGN	-27.18550	-3.437108	-2.864412	-2.568352
TEL	-36.26241	-3.435267	-2.863599	-2.567916
BIO	-35.15009	-3.434677	-2.863338	-2.567776
BVB	-18.04094	-3.448312	-2.869351	-2.570999
AZO	-58.59668	-3.432003	-2.862156	-2.567141
BRK	-34.44749	-3.434224	-2.863138	-2.567669