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Market Efficiency and Day of the Week Effect in the Romanian Stock Market

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Abstract: The presence of calendar anomalies and other such effects in stock markets constitute evidence of an inefficient market on the short term and investors could take advantage of these effects to further increase their profits. Therefore, the main objective of this paper is to determine if calendar anomalies exist in the Romanian stock market. This research began with a review of the literature surrounding the Efficient Market Hypothesis (EMH) followed by an empirical study regarding the day of the week effect in the case of the Romanian Stock Market. The dataset consists of daily closing values for the analyzed indicators, from July 31st, 2013, until August 18th, 2023. We investigated the day of the week effect, in the Bucharest Stock Exchange (BSE) market using the daily closing values of Bucharest Exchange Trading Index (BET) and as proxy for the world market portfolio, we chose the Dow & Jones industrial average and the S&P 500. The initial research results suggested a statistically significant Tuesday effect that is in accordance with the literature. Upon further analysis, and after considering the seasonality component of the global markets, estimated by an ARCH & GARCH model, we obtained that the Tuesday coefficient is, in this instance, decreased. Thus, indicating that although the day of the week effect is present in the BSE market, it is caused by the global market's seasonality component rather than by an endogenous anomaly in the Romanian stock market. These findings suggest that the efficiency of the BSE market might be affected on the short-term.

Keywords: efficient market hypothesis; calendar anomalies; Romanian stock market

1. Introduction

In this paper we discussed the Efficient Market Hypothesis (EMH) in all its forms as formulated by Fama (1970). We explored the literature regarding EMH and equilibrium models alongside other statistical and mathematical methods for estimating market efficiency. Furthermore, we proposed to test for the day of the week effect in the Romanian Stock Market. If these kinds of anomalies are present in markets, their efficiency might be affected in the short-term. Such effects are known in the literature as calendar anomalies. This study's primary goal is to determine whether the day of the week exists in the Romanian stock market. Calendar anomalies and other such effects constitute evidence of an inefficiency in the market on the short-term. If such anomalies are present in stock markets, investors can take advantage of these effects to further increase profits. The alternative to buy and hold or dollar cost averaging (DCA) is speculative in nature. Investors shall find and exploit market price variation for their own advantage. This topic's implications are of great importance for academics as well. Calendar anomalies such as: January effect, day of the week effect, turn of the month effect, Halloween effect and others, only appear in inefficient markets.

An inefficient market can be described as a market in which all available information regarding the price of a security is not fully and freely available to all investors and investors do not all agree on the implications of this information. As we can see from the literature, the day of the week patterns have been exhaustively discussed and studied. Mean returns and distributions of stock prices varies according to the day (see Cross, 1973; French, 1980; Keim & Stambaugh, 1984; Rogalski, 1984; Ajayi et al., 2004; Berument & Kiymaz, 2001; Enescu Student, n.d.; Plastun et al., 2019). The common finding of these above-mentioned studies are mean negative returns on Monday in the historical perspective. The reasons behind such low returns on Monday have led psychologists to hypothesize that this could be because of a pessimistic outlook following the weekend and the beginning of a new work week. Investors might be stressed due to the work that awaits them ahead. This phenomenon has been observed on the first trading day of the week, which is typically Monday; however, the effect is still evident in most Middle Eastern countries where the first day of the week is Sunday (see Shehadeh & Zheng, 2023). More realistically speaking, lower returns on Monday are due to the weekend effect. Investors who are averse to risk prefer to close positions on Friday and exist the market during the weekend. News that are not usually optimistic appear during the weekend causing the market to react Monday morning (as it is closed during the weekend).

An anomaly in which the month of January has statistically significant mean returns higher than the rest of the year. Emotion is which drives stock prices more than anything else. These anomalies arise due to the collective emotions, spirit, and mental state of the investors. For example, investors are more likely to have elaborate investment plans, purchase more securities, and drive-up prices in the first month of the year when they are optimistic about the new year and its prospects. This kind of optimism and pessimism among investors is of quite importance in market fluctuations. Another importance of this topic is sensibility to the global market risk and seasonality. Emerging markets are more prone to be influenced by the seasonality of developed markets, this is quite perfectly reflected in the saying "If the USA sneezes, the whole world catches a cold" In the literature this phenomenon was studied using models that account for time-varying volatility such as ARCH and GARCH models.

Considering all this, the objective of our research was to empirically test the day of the week effect in the Romanian stock market.

We used the daily closing values of Bucharest Exchange Trading Index (BET) from 2013 to 2023, the closing values for the same period for both the S&P500 and The Dow & Jones industrial average from www.dow.com, to serve as a proxy for the world market portfolio and to account for the seasonality in returns. We calculated the one period returns for the entire data set and proceeded with an OLS regression model at first, followed by goodness of fit tests such as Breusch-Pagan test for heteroskedasticity, Breusch-Godfrey test for autocorrelation, and elaboration of a correlogram to further inspect the heteroskedasticity of residuals. An autoregressive conditional heteroskedasticity model was applied to the BET daily return index values as a function of the day of the week and global market risk. Elaboration of ARCH & GARCH model was done by considering the time-varying volatility of our residuals.

The rest of the paper is structured as follows: Literature Review, Methodology and data, Results and discussion and Conclusions.

2. Literature Review

The study of calendar anomalies and market efficiency have been already exhaustively discussed in the literature from the 1960's onwards (see DIMA et al., 2021; Dima & Milo, 2009; Dimson & Mussavian, 1998; Fama, 1970; Fama et al., 1969; Pleşoianu et al., 2012). For discussions on the random walk hypothesis and measurements of the efficiency of capital markets see Beran, 1992; Dittrich & Srbek, 2020; Fama, 1965, 1970b; Fama et al., 1969; Mandelbrot', n.d.; Mandelbrot & Hudson, n.d.

Fama (1970) has defined that the capital market's main concern is ownership allocation of the economic capital in the most efficient, direct, and transparent way possible. An efficient market described by Fama (1970) is a market in which all necessary information regarding a security is freely available and accessible to all participants, and at the same time, it requires that all investors agree on the implications of this freely available information. Everyone must believe that a security's price is determined equitably by the market, that it is independent of its own historical values, and that nothing and no one can alter how future prices are distributed. Fama identified and described three levels of market efficiency, the weak-form, the semi-strong form, and the strong-form efficiency.

According to Fama (1970), the principal role of capital markets around the world is ownership allocation of economic capital. The ideal market is one in which prices of securities fully reflect all available information at any given time, and all investors agree with the information available. He provided economists with three simple conditions that are sufficient to consider any market efficient:

(i) there are no trading costs, commissions and other expenses for investors trading securities,
(ii) all information is available free of charge and easily accessible to all investors, at any given time;
(iii) all investors agree with the implications of current information for the current price and distributions of future prices for each security.

In a market that satisfies all the above conditions, obviously, is a market in which security prices fully reflect all given information, but such a frictionless market is not characteristic of markets met in practice.

The weak form of the Efficient Market Hypothesis (EMH) states that the previous prices of a given security are the sole relevant data set for determining its present price. Investors shouldn't anticipate seeing any trends in the security's past pricing that may be used to build complex trading strategies and increase profits. The random walk model was employed in most of the literature to investigate this weak form of EMH. Changes in pricing resulting from new information will appear random since new information is assumed to arrive in an unforeseen way. As a result, price changes in a weak-form efficient market are independent of one another and happen at random. Studies of past prices of a given asset cannot reliably produce excess returns if a market is weak-form efficient since there is no correlation among subsequent prices. Because it is based solely on analyzing historical price patterns without considering any additional contextual information, this type of research is known as technical or chart analysis. Eugene Fama claimed in 1965 that the random walk theory could not fully capture reality, in his study on the behavior of stock market prices (Fama, 1965).

Moving forward to the semi-strong form of EMH, it asserts that a market is efficient if the price of a security quickly reflects every relevant piece of information that is available to the public, regarding that security. According to this form of efficiency, the market will swiftly adjust prices to a new equilibrium level that reflects the shift in supply and demand brought about by the release of pertinent new information. The semi-strong form of the EMH gains empirical strength despite its possible lack of intellectual rigor because it is easier to test than the strong form. When considering all publicly available information regarding the risk and return of an investment, the current market price is the best available unbiased predictor of a fair price in a market that is semi-strong efficient. Analysis of any available data, not just historical pricing, cannot produce a steady stream of excess returns. This is a slightly more contentious conclusion than the weak- form EMH because it implies that fundamental analysis, or the methodical examination of businesses, industries, and the economy, is incapable of yielding returns that are greater than those that are warranted by chance. Such a theory cast doubt on the importance and usefulness of investment research and analysis.

In its most robust version, the strong form of the Efficient Market Hypothesis (EMH) states that a market is efficient when the market price promptly and accurately reflects all relevant information regarding a share's value, regardless of whether it is generally available to current or potential investors. For instance, the holders of confidential information will purchase shares to take advantage of the pricing anomaly if the current market price is less than the value supported by that information. They intend to persist in this manner until the price of the shares reaches the level substantiated by their confidential information, given the positive demand for them. They will then be unmotivated to keep purchasing, leaving the market, and the price will level off at this new equilibrium. Calendar anomalies are another crucial subject in the EMH debate. These anomalies, which cannot occur when the market behaves as an efficient one, provide evidence against the EMH.

The most studied anomalies are: the month-of-the-year effect, the day-of-the-week effect, the turn-of-the-month effect, the holiday effect, the week-of-the-year effect, January effect, the Halloween effect, etc. It is important to conduct research on these effects and how they affect investors and academics. Rather than employing buy and hold as a long-term strategy, investors who base their strategy on speculation and are not risk-averse can take advantage of these effects to further increase returns, in short periods of time. As the literature demonstrates, these effects can be used to take advantage of variations in market prices. Scholars can gain insight into how global markets function by examining these anomalies.

Less visible anomalies like the Halloween effect as in (Bouman & Jacobsen, 2002) imply that investors elaborate medium term strategies to gain from these kinds of anomalies. When the bear market begins, usually around the end of May and lasts until October, investors sell all their assets and securities, a tactic known as the "Halloween effect" or "Sell in May and go away". This implies holding cash in the period of May – October when stock market returns are significantly lower than the rest of the year and rejoin the stock market in November. Of course, this kind of behavior is exactly what Dimson & Marsh (1998) describe as Murphy's law in the stock market. In this scenario, the bear market that begins in May is caused by investors who decide to sell because they think the market may experience a downturn rather than by some outside "force.". Because enough investors chose to sell and think that the bear market would begin, the market will now actually experience a downturn rather than the other way around. Dimson and Marsh (1998) say that such behavior is the one causing these kinds of anomalies.

Ţilică & Oprea (2014) studied the day of the week effect in the Romanian stock market using daily closing data of BET from 2005 until 2011 and found the presence of the Friday effect and that seasonality in the stock market returns is closely correlated with the global market risk. Diaconasu et al. (2012) studied the presence of the day of the week effect and month of the year effect on the Bucharest Stock Exchange market for the period of 2000 – 2011. They observed a statistically significant Thursday effect for the period analyzed but did not find any traditional Monday effect. For the entire sample period, the January effect was not present, thus concluding that the Romanian equity market was reasonably efficient from 2000 – 2011. Enescu (2022) also studied the day of the week effect and January effect in BSE from 2002 until 2022 dividing the series into three subperiods and employing and OLS dummy regression. The Thursday effect was confirmed for this period, but the January effect was only confirmed for the subperiod 2003 – 2007. Concluding that the changes in market conditions for this period have drastically reduced the possibility of speculating from market anomalies.

From a historical perspective, Berument & Kiymaz (2001) have studied the day of the week effect on the S&P 500 from 1973 until 1997. For this period the day of the week effect was present with the highest and lowest returns observed on Wednesday and Monday. Patev & Kanaryan (2003) reported negative Monday returns in Romania between 1997 to 2000 thus confirming the presence of a Monday effect. Results seem contradictory at times depending on the approach of the researcher. Ajayi et al. (2004) tested for the day of the week effect in emerging markets of Eastern Europe and did not find the presence of such anomaly. Heininen (2008) reported the disappearance of such anomalies in Central and Eastern Europe after joining the EU. Borges (2009) observed the presence of the day of the week effect only in the Slovenian stock market after joining the EU.

3. Methodology and data

The research started with identifying the calendar anomalies such as the day of the week effect, which if present suggests that the efficiency of the market might be affected in the short term.

The dataset used in this paper was created using the following variables: (1) Bucharest Exchange Trading Index - BET which is a market capitalization weighted index, and its value reflect the price movement of all companies listed on the I^{st} and II^{nd} category of the Bucharest Stock Exchange (BSE) and was obtained from www.bvb.ro; (2) The Dow & Jones industrial average; (3) And the S&P 500 which both were obtained from www.dow.com and serve as a proxy for the world market portfolio. The applied dataset consists of daily closing values for all afore mentioned indices, from July 31st 2013 until August 18th 2023.

The efficient market hypothesis tells us that the price of a security J at time T fully reflects all available information, thus Fama (1970) wrote the following equation to describe the relation:

$$E(p_{j,t+1}|\Phi_t) = [1 + E(r_{j,t+1}|\Phi_t)]p_{jt}$$

Where E is the expected value; p_{jt} is the price of security j at time t; $p_{j,t+1}$ is the price at time t+1; $r_{j,t+1}$ is the one period change in returns; Φ_t denotes the information that is assumed to fully reflect in the price of the security at time t. It is assumed however that the information contained in Φ_t at time t is fully utilized in determining current equilibrium of expected returns.

The relationship described above has a major implication in empirical work, if current equilibrium of returns fully reflect all given information in Φ_t, this completely rules out the elaboration of trading systems based solely on information Φ_t that have expected profits more than equilibrium expected profits. If

$$x_{j,t+1} = p_{j,t+1} - E(p_{j,t+1}|\Phi_t)$$

Then

$$E(x_{j,t+1}|\Phi_t) = 0$$

The sequence $\{x_{j,t}\}$ is a "fair game" process in respect to the information sequence $\{\Phi_t\}$, $x_{j,t+1}$ is the excess market value of security j at time t, which by definition of the efficient market, it has to be equal to zero as described above. Thus, lastly, we must assume that:

$$E(p_{j,t+1}|\Phi_t) \geq p_{jt}$$

the price sequence $\{p_{jt}\}$ of security j at time t follows a submartingale with respect to the information denoted in $\{\Phi_t\}$, and this tells us that the expected value of next period's price, as projected based on information $\{\Phi_t\}$ is equal to or greater than the current price.

If calendar anomalies are present in markets met in practice, the price of security j at time t does not fully reflect the information sequence $\{\Phi_t\}$, and thus the price sequence $\{ p_{jt}\}$ will not be equal to or greater than the current price of the security. The expected value operator in respect to the information sequence $\{\Phi_t\}$,

$$E(x_{j,t+1}|\Phi_t) \neq 0$$

will not equal to zero, and thus it renders the market inefficient.

A market that is conditional value operator incorporates beside the information sequence denoted as $\{\Phi_t\}$, an additional specific set of information regarding a particular day of the week (i.e., day-of-the-week effect) can be written as follows:

$$E(p_{j,t+1}|\Phi_t + \mathrm{D}_{it}) = [1 + E(r_{j,t+1}|\Phi_t + \mathrm{D}_{it})]p_{jt}$$

And

$$x_{j,t+1} = p_{j,t+1} - E(p_{j,t+1}|\Phi_t + \mathrm{D}_{it})$$

Then

$E(x_{j,t+1}|\Phi_t + \mathrm{D}_{it}) \neq 0$ or $E(x_{j,t+1}|\Phi_t + \mathrm{D}_{it}) \ngeq p_{jt}$

We have calculated the one period returns for the indices using the following formula:

$$R_{j,t} = ln\left(\frac{P_{j,t}}{P_{j,t-1}}\right) * 100$$

Where $R_{j,t}$ is the return of index j at time t; $P_{j,t}$ is the price of index j at time t; $P_{j,t-1}$ is the price of index j at time t-1.

After computing the one period returns for each index included in our analysis, we proceed with tabulating the dummy variables for each day of the week. Let $\{D_{it}\}$ be $\{D_{it}\}$ ϵ [1, 2, 3,4,5] the sequence of days in one business week (Monday through Friday), and if D_{jt} = Monday then $\{D_{it}\}$ ϵ [1, 0, 0,0, 0]; if $D_{it} \neq$ Monday (lets say it is a Tuesday) then $\{D_{it}\}$ ϵ [0, 1, 0, 0, 0], and so forth for each day of the week. Lastly, we have calculated the proxy for world market risk (return) using the Dow & Jones industrial average and the S&P500. After calculating the returns, we determined the RWM proxy such as:

$$Rwm = R_{Dija} + R_{Sp500}$$

Where, RWM is return of world markets; R_{Dija} is the one period return of DIJA; R_{Sp500} is the one period return of the S&P500.

To proceed further with our analysis, as we are dealing with time series financial data, we must test the stationarity of our series. To model this kind of data, unit-root must be assumed. Let p_t= $p_{t-1} + u_t$where u_t~ IID (0, σ_t^2), then p_t would be a random walk. Indeed, some economists believe that stock market prices and indices follow a random walk, meaning that the price of a stock today is the price of the stock from yesterday plus a random shock. If this assumption is true, a random walk is a non-stationary time-series, and thus we cannot obtain an estimable model. Any shock received by the stock price will be permanent and will not decay rapidly like other AR (1) processes. We can say that if the initial price of the stock is

$p_0 = u$, then p_1= $u + u_1$, then p_2= $u + u_1 + u_2$,…, and so on p_t=$u + \sum_{j=1}^{t} u_j$. As we pointed out earlier, the variance of p_t is dependent on t and p_t is not covariance stationary. Fixing this problem implies first differencing p_t to get u_t which is stationary (see Baltagi, 2011).

The Augmented Dickey-Fuller test has been applied to our dataset in the following way: First, we tested the stationarity of all indices closing values for the entire period, which of course, are non-stationary, and the p-values are all greater than 0.05 thus rejecting the null. Applying first differences such as Δp_t= $p_t - p_{t-1}$ we get a stationary series. The Augmented Dickey-Fuller test conducted on first differences Δp_t made us accept the null (all p-values < 0.001) and conclude that our series is stationary at first level .As we move further to testing the stationarity of our return variable for each index, as we calculated it with the above mentioned formula and obtained the one-period % change in returns, the Dickey – Fuller test confirmed that the data is stationary at level and has unit-root (p-value <0.001).

To test if the day-of-the-week effect is present in the Bucharest Stock Exchange market, we continue with a simple OLS regression. Let $\{R_{jt}\}$ be a function of $\{D_{it}\}$ ϵ [1, 2, 3,4,5] such as $f_{(R_{j,t})}$= $\sum_{i=1}^{5} \beta_i D_{it}$ Or $R_{j,t}$= $f\left(\sum_{i=1}^{5} \beta_i D_{it}\right)$, then we obtain:

$R_{j,t}$= $\alpha_0 + \sum_{i=1}^{5} \beta_i D_{it} + \epsilon_i$,

Where $R_{j,t}$ – return index of BET; α_0- mean Monday return; $\{D_{it}\}$ sequence of days; and ϵ_i is our error term which satisfies ϵ_i ~ N (0 | σ^2).

If we estimate the above model, we will not get a Monday coefficient like the other days, thus we removed the constant α_0 from the equation and obtained:

$R_{j,t}$= $\sum_{i=1}^{5} \beta_i D_{it} + \epsilon_i$

Where $R_{j,t}$ – return index of BET; $\{D_{it}\}$ sequence of days; and ϵ_i is our error term which satisfies ϵ_i ~ N (0 | σ^2).

After estimating the model using OLS, we run the Breusch-Pagan Test for heteroskedasticity, with a p-value less than 0.05 we cannot accept the null and must assume that heteroskedasticity is present among the residuals. To further inspect the heteroskedastic potential of our residuals, we computed a correlogram and observed that constant variance was not achieved.

The data might be autocorrelated due to the nature of financial time-series, therefore we tested it using Breusch-Godfrey LM test for autocorrelation. The p-value of the test was less than 0.05 making us reject the null and declare that autocorrelation is present. To fix this issue we added the lag operator of our dependent variable such as $\Delta R_{j,t} = R_t - R_{t-1}$,and added the world market returns to the initial equation and obtained the following model:

$$R_{j,t} = \sum_{i=1}^{5} \alpha_i D_{it} + \sum_{i=1}^{5} \beta_i RWM_t + \sum_{j=1}^{n} \gamma_j R_{t-j} + \epsilon_t$$

Where $R_{j,t}$– return index of BET; $\{D_{it}\}$ sequence of days ; RWM_t – return of world market; R_{t-j} – lag of BET; $\alpha_i, \beta_i, \gamma_j$ – regression coefficients; ϵ_t – error term which is $\epsilon_t \sim IID(0,1)$.

The error term must satisfy ϵ_i ~ N (0 | σ^2) however the variance of ϵ_i is dependent on t, this may result in incorrect estimations. Because heteroskedasticity exists, we must include the time-varying variance into the equation to model the volatility of our series.

The expected value operator in respect to the sequence of days $\{D_{it}\}$ and as a time-varying function of world market return and of its own stochastic process can be written as follows:

$$E(r_{j,t+1} | D_{it}) = f(x) \left[\sum_{i=1}^{5} \beta_i RWM_t + \sum_{j=1}^{n} \gamma_j R_{t-j} + \sigma_t^2 \right]$$

Where E is the expected value of BET returns at time t+1 regarding the days sequence $\{D_{it}\}$ and as a time-varying function.

To obtain a testable model that can be estimated using feasible GLS or maximum likelihood, the days sequence $\{D_{it}\}$ regarded as the bases of the expected value of r at time $t+1$ has been included as a variable in the function of the world market portfolio and past returns values such as

$$E(r_{j,t+1} | f_{(X)}) = \sum_{i=1}^{5} \alpha_i D_{it} + \sum_{i=1}^{5} \beta_i RWM_t + \sum_{j=1}^{n} \gamma_j R_{t-j} + \sigma_t^2$$

thus, we can say that

$$R_{j,t+1} = 1 + \left[\sum_{i=1}^{5} \alpha_i D_{it} + \sum_{i=1}^{5} \beta_i RWM_t + \sum_{j=1}^{n} \gamma_j R_{t-j} + \sigma_t^2 \right]$$

Or

$$R_{jt} = \sum_{i=1}^{5} \alpha_i D_{it} + \sum_{i=1}^{5} \beta_i RWM_t + \sum_{j=1}^{n} \gamma_j R_{t-j} + \sigma_t^2$$

And

$$\sigma_t^2 = \gamma_0 + \gamma_1 u_{t-1}^2 + \delta_1 \sigma_{t-1}^2$$

Where the conditional variance of u_t depends upon q of its lagged values and as well as on p of the squared lagged values of u_t

With the basic GARCH model specification elaborated above, we tested for any remaining ARCH effects using the Lagrange Multiplier test for ARCH effects as in Engle.

4. Results and discussion

We have defined earlier that calendar anomalies constitute evidence against the efficient market hypothesis. For those who are making use of such phenomena to generate additional profits, calendar anomalies and other trading systems based on day-to-day price fluctuations in securities provide an unfair advantage.

The summary statistics of the analyzed indicators is presented in Table 1.

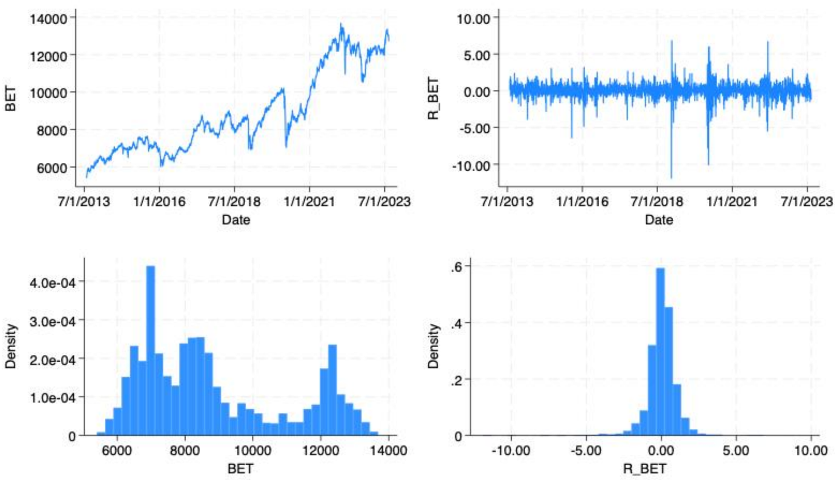
Table 1. Summary statistics.

	N	Mean	Median	SD	Min	Max	Kurt.	Skew.
BET	2515	8838.748	8274.540	2149.476	5403.6	13681.92	2.114	.657
R BET	2515	.034	0.060	.979	-11.89	6.82	23.542	-1.579
DIJA	2515	24512.037	24706.350	6545.099	14776.13	36799.65	1.703	.227
R DIJA	2514	.033	0.056	1.107	-13.842	10.764	25.839	-.954
SP500	2515	2889.468	2723.060	881.534	1630.48	4796.56	1.973	.53
R SP500	2514	.039	0.059	1.118	-12.765	8.968	19.257	-.815
Day	2515	3.011	3.000	1.408	1	5	1.712	-.007

Source: own computing using STATA 18 software

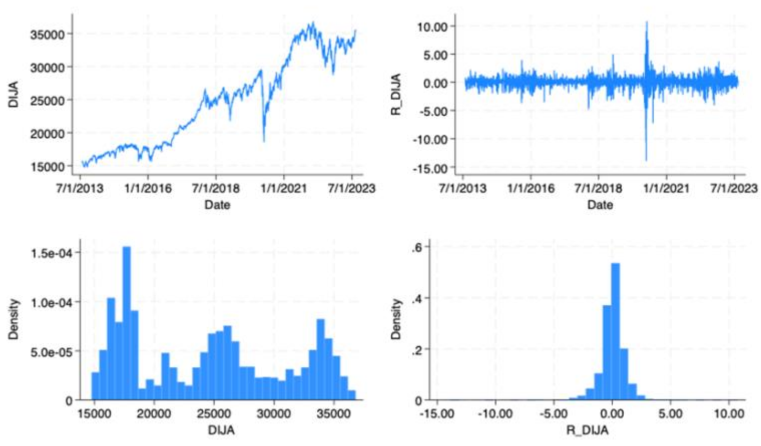
In all cases kurtosis is greater than 3, having leptokurtic distributions we can expect high volatility and risk potential. This high level of kurtosis (greater than 20) is to be expected when working with financial data such as stock prices.

From Figures 1 through 3 we can see the distributions of all indices and their respective daily returns.



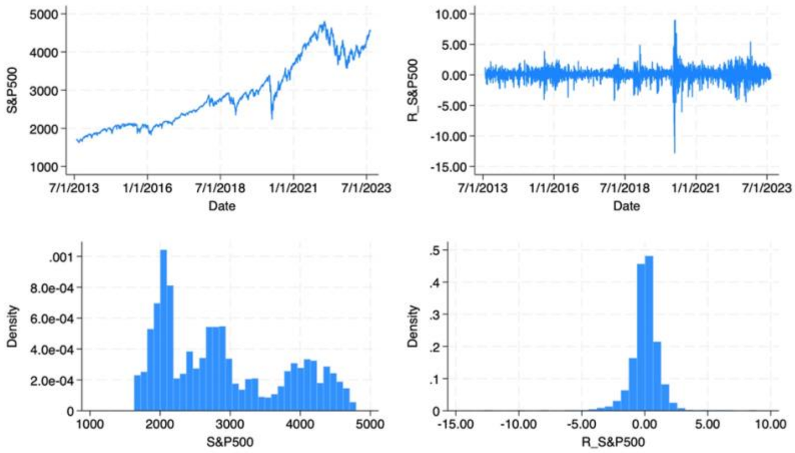
Source: own computing using STATA 18 software

Figure 1: Trend & Volatility and distributions of BET between 2013-2023



Source: own computing using STATA 18 software

Figure 2: Trend & Volatility and distributions of DIJA between 2013-2023



Source: own computing using STATA 18 software

Figure 3: Trend & Volatility and distributions of S&P500 between 2013-2023

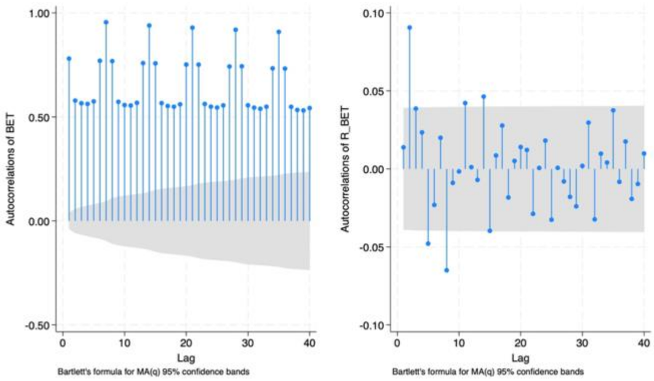
Fatter tails are found in all three histograms. If we pay attention to the returns and their according histograms, we might say that they follow a normal distribution. The histograms for returns are dense in the center with no visible tails. This kind of histogram follows a bell-shaped Gaussian distribution suggesting that returns are indeed random and IID ~ N(0 | σ^2). This independence does not hold however when computing the autocorrelation and partial autocorrelation of each index and their respective returns.

The dynamic of BET, DIJA and S&P500 in period 2013-2023 can be seen in Figure 4.

Figure 4: Dynamics of BET, DIJA and S&P500 (non-logarithmic scale) 2013-2023

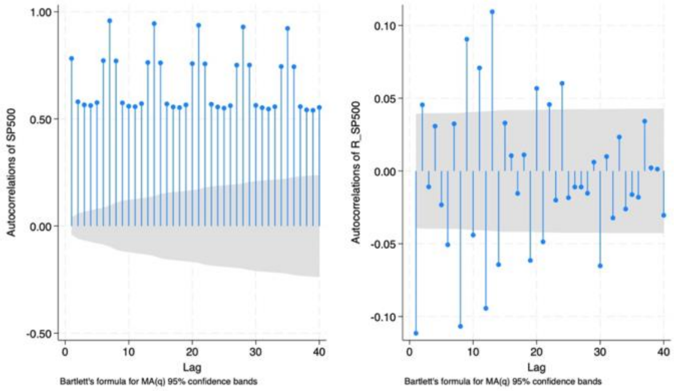
Source: own computing using STATA 18 software

The autocorrelations of BET, DIJA and S&P500 are presented in Figure 5 through Figure 7. By including 40 lags, we see that the present value of BET is autocorrelated with its own past values over the 40-day period. This implies that the weak form of EMH asserts relevancy in determining current prices of a security only on historical prices of that security that are indeed random as new information arises randomly in the market.



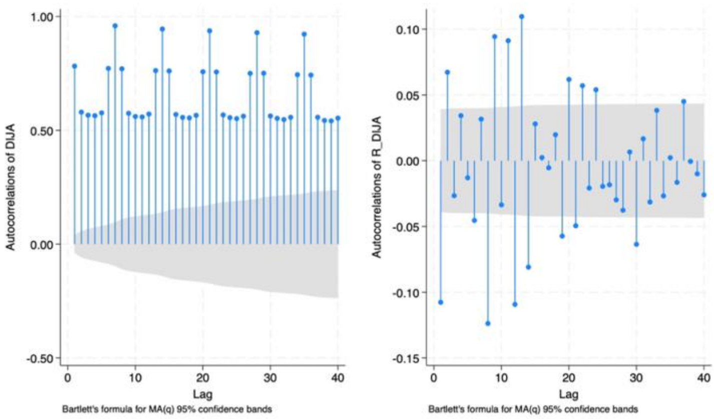
Source: Own computing using STATA 18 software

Figure 5: Autocorrelation of BET & BET Returns including 40 lags



Source: Own computing using STATA 18 software

Figure 6: Autocorrelation of SP500 & SP500 Returns including 40 lags



Source: Own computing using STATA 18 software

Figure 7: Autocorrelation of DIJA & DIJA Returns including 40 lags

Present values of BET are influenced by their own past values and do not follow a random walk. RWH tells us that tomorrow's price is equal to today's price plus a random shock. Nor does a "fair game" model that states the impossibility of elaborating trading systems to obtain higher returns than equilibrium returns hold in this case. For the "fair game" model to be valid, all past lag values and serial covariances must be zero which in our case, they are not (Fama, 1970).

The normality of our data was tested using the Ljung-Box test, Jarque-Bera test and the Skewness and Kurtosis test for normality. All test results and their according p-values are found in Table 2. All tests reject the hypothesis of normality, the data is not normally distributed.

Table 2. Ljung-Box, Jarque-Bera and Skewness and Kurtosis tests for normality

	Ljung-Box	Pr(skew.)	Pr(kurt.)	chi2(2)	Prob>chi2	Jarque-Bera (Chi-squared)
BET	45607.936 (p-value=0.000)	0.000	0.000	468.430	0.000	263.4
R BET	82.591 (p-value=0.000)	0.000	0.000	1198.610	0.000	4.5e+04
DIJA	46385.052 (p-value=0.000)	0.000	0.000	7024.360	0.000	198.0
R DIJA	294.405 (p-value=0.000)	0.000	0.000	941.150	0.000	5.5e+04
SP500	46367.652 (p-value=0.000)	0.000	0.000	752.070	0.000	228.2
R SP500	249.266 (p-value=0.000)	0.000	0.000	792.470	0.000	2.8e+04

Source: own computing using STATA 18 software

From the results reported in Table 3 we can see a statistically significant coefficient for Tuesday, this means that in the analyzed period, Tuesday had abnormally high returns in comparison with other days.

Table 3: OLS Regression Results and ARCH & GARCH Estimations

	(1) OLS	(2) OLS with RWM	(3) ARCH / GARCH
Monday	-0.0165	-0.0195	-0.0142
	(0.0442)	(0.0442)	(0.0253)
Tuesday	0.145^{***}	0.147^{***}	-0.0350
	(0.0435)	(0.0434)	(0.0234)
Wednesday	-0.00490	-0.0102	-0.0282
	(0.0433)	(0.0434)	(0.0243)
Thursday	0.0105	0.00847	-0.00624
	(0.0435)	(0.0435)	(0.0237)
Friday	0.0341	0.0318	0.0131
	(0.0436)	(0.0436)	(0.0239)
R_{DIJA}		-0.0918	
		(0.0652)	
$R_{S\&P500}$		0.132^{*}	
		(0.0646)	
RWM			0.504^{***}

			(0.00353)
$R_{BET,t-1}$			0.0406***
			(0.0114)
ARCH			
μ_{t-1}^2			0.339***
			(0.0212)
σ_{t-1}^2			0.565***
			(0.0419)
α_0			0.0415**
			(0.0146)
N	2515	2514	2514
R^2	0.005	0.008	

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Source: own computing using STATA 18 software

This finding is in line with the Tuesday Effect in the literature (Berument & Kiymaz 2001). Other studies conducted on the Bucharest Stock Exchange found the presence of Thursday and Friday effect (Diaconasu et al. 2012; Tilica & Oprea 2014; Enescu 2022).

All studies mentioned found that between 2000 and 2011 there were negative returns for Tuesday and abnormally high returns for Thursday and Friday. This finding suggests that investors (for the period of 2000 – 2011) should have bought securities on Tuesday and sold on Thursday or Friday for extra profits. But indeed, nature can be perverse and according to Dimson & Marsh 1998, if enough investors discover that stock prices are lower on Tuesday and higher on Friday, they will buy on Tuesday, driving up prices, and sell on Friday, driving down prices.

Global markets are subject to Murphy's law, which states that if enough investors take advantage of these calendar anomalies, the markets will reverse, and the opposite will occur. (i.e. higher prices on Tuesday and lower on Friday).

This theory is consistent with the study's findings. Between 2013 and 2023 (our sample period) the returns have flipped. Tuesday has the highest mean return of the week, and Thursday and Friday lower than Tuesday. Monday and Wednesday have negative mean returns, indicating that traders may create complex plans to buy on Monday and Wednesday and sell on Tuesday of the following week. However, if enough traders take advantage of this anomaly, it will eventually reverse, making Tuesday returns negative and producing unusually high returns on Monday and Wednesday.

In model (2) we also see a significance for the Return of S&P 500 coefficient, thus suggesting that besides a relationship between Tuesday returns and BET, we can assume that a positive change in the S&P500 returns will transfer to an increase in BET returns, this makes the BSE market sensible to the S&P500 (this findings are also validated by Diaconasu et al. 2012; Tilica & Oprea 2014; Enescu 2022;). This kind of relationship between the BSE market and other more influential indices such as the S&P500 makes the Romanian stock market sensible to changes in the global market. This sensibility is primarily the result of market integrations brought about by globalization.

The hypothesis of seasonality in returns and lack of market efficiency in the analyzed period was accepted, as the α_i coefficients of the tested model were statistically significant. The initial statistically significant coefficient for Tuesday returns decreases and becomes insignificant as we estimate the ARCH / GARCH equation.

Model (3) suggests that the day of the week effect in the Romanian stock market is due to seasonality in the world market returns, and to the sensibility of BSE to exogenous shocks and not due to endogenous anomalies. The findings of this study serve as evidence against the efficient market hypothesis in the case of Romania and are in line with studies such as Dragotă & Ţilică (2014); Dragota et al. (2009);

Further inspection of seasonality in returns can be conducted using an additive decomposition method of the time series such in obtaining the trend (or cycle) the seasonal component and the noise. Such decomposition can be done by employing an unobserved component model and predicting the seasonal component of that model.

The result show the cycle (a period of 12 month for example) and the remaining noise of the time series that has been decomposed. This decomposition can tell us if the day of the week effect (and other calendar anomalies) are in fact an outcome of the global market or are there any other factors that influence the returns according to the day of the week. Indeed, our results suggest that there is a seasonal component causing the disturbances in returns according to the days of the week. The risk-return relationship between the world market portfolio and BET is significant in explaining the causality of these anomalies. Of course, the other important aspect of these anomalies is investors behavior.

5. Conclusions

This paper studied the Efficient Market Hypothesis in its weak, semi-strong and strong form as formulated by Eugene Fama in his 1970 paper. Furthermore, it examined the calendar anomalies in the case of the Romanian Stock market.

The findings of this study suggest that a Tuesday effect is present in the Bucharest Stock Exchange market but when considering the seasonality of market returns, the Tuesday coefficient fades until it becomes unsignificant. This leads to the conclusion that the day of the week effect in the Romanian stock market is present due to the influence of the global market, and not due to some intrinsic cause.

In both models (1) and (2) we obtained a statistically significant coefficient for Tuesday. This coefficient suggests that in the studied period Tuesday had abnormally high returns in comparison to the other days of the week. This finding tells us that investors should have bought on Monday and Wednesday (the days with a negative coefficient) and sold on Tuesdays for an extra profit.

The behavior and exploitation of this effect led investors to buy on Tuesday (because prices were lower) and sell on Thursday or Friday (when prices were higher). This behavior determined in the next period (2013-2023 period of our analysis), a statistically significant raise in Tuesday returns (because enough investors decided to buy, they ramped up prices) and lower returns on Thursday and Friday (when investors decided to sell, and so prices went lower). The study’s conclusions supports Murphy’s Law which Dimson & Marsh (1998) proposed, and show that the efficiency of the BSE market might be affected in the short term.

To further inspect the relationship of the world market portfolio and BET, an ARCH & GARCH model was elaborated to take the time varying component into model estimation. The informational shock of a financial time series data such as stock prices does not rapidly decay like an AR (1) model, and in this instance the time-varying volatility of the series must be considered. Since the initial shock might not become apparent in the data for some time, an autoregressive conditional heteroskedastic model was employed to account for this evolution.

The estimation of model (3) determined the Tuesday coefficient to fade until it became unsignificant. This finding suggests that the day of the week effect is present in the BSE market due to the seasonality component of the global market portfolio and not due to some endogenous anomaly.

Further research of calendar anomalies in the Romanian stock market can be done by using more indices and not just BET. This analysis can also be extended to other Romanian markets such as the Bond Market and with individual listed companies as well. The seasonality component can be further elaborated on by conducting individual studies of different economic sectors in the same period to see if one is more prone to higher returns that the other according to the time of the year or the current economic cycle. Estimation of efficiency for the Romanian market can be done by employing R/S analysis as in Mandelbrot 1972, estimating the fractal dimension for short term memory and Hurst exponent for long term memory of the series.

One of our study's limitations is that historical BET closing values are not readily available and information about the Bucharest Stock Exchange is not easily accessible. Other limitations regarding the dataset used are in relation to the global market portfolio proxy we elaborated. One could extend this proxy by incorporating indices from stock markets across the world such as the New York Stock Exchange, London Stock Exchange, Tokyo Stock Exchange, Deutsche Börsa; Singapore Stock Exchange, Australian Securities Exchange, and many others.

Supplementary Materials: The following supporting information can be downloaded at: www.mdpi.com/xxx/s1, Figure S1: title; Table S1: title; Video S1: title.

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References

1. AJAYI, R. A., MEHDIAN, S., & PERRY, M. J. (2004). The Day-of-the-Week Effect in Stock Returns : Further Evidence from Eastern European Emerging Markets. *Emerging Markets Finance and Trade*, *40*(4), 53–62. https://doi.org/10.1080/1540496X.2004.11052582
2. Beran, J. (1992). Statistical Methods for Data with Long-Range Dependence. In *Science* (Vol. 7, Issue 4).
3. Berument, H., & Kiymaz, H. (2001). The day of the week effect on stock market volatility. *Journal of Economics and Finance*, *25*(2), 181–193. https://doi.org/10.1007/BF02744521
4. Borges, M. R. (n.d.). *Calendar Effects in Stock Markets: Critique of Previous Methodologies and Recent Evidence in European Countries School of Economics and Management*.
5. Bouman, S., & Jacobsen, B. (2002). The Halloween Indicator, "Sell in May and Go Away": Another Puzzle. *American Economic Review*, *92*(5), 1618–1635. https://doi.org/10.1257/000282802762024683

6. Cross, Frank. (1973). The Behavior of Stock Prices on Fridays and Mondays. *Financial Analysts Journal*, *29*(6), 67–69. https://doi.org/10.2469/faj.v29.n6.67
7. Diaconasu, D.-E., Mehdian, S., & Stoica, O. (2012). An Examination of the Calendar Anomalies in the Romanian Stock Market. *Procedia Economics and Finance*, *3*, 817–822. https://doi.org/10.1016/S2212-5671(12)00235-3
8. DIMA, B., DIMA, Ș. M., & IOAN, R. (2021). Remarks on the behaviour of financial market efficiency during the COVID-19 pandemic. The case of VIX. *Finance Research Letters*, *43*. https://doi.org/10.1016/j.frl.2021.101967
9. Dima, B., & Milo, L. R. (2009). Testing the_Efficiency_Market_Hypothesis in Romania. In *Annales Universitatis Apulensis Series Oeconomica* (Vol. 11, Issue 1).
10. Dimson, E., & Marsh, P. (1998). *{PRIVATE } MURPHY'S LAW AND MARKET ANOMALIES*.
11. Dimson, E., & Mussavian, M. (1998). A brief history of market efficiency[We have be]. *European Financial Management*, *4*(1), 91–103. https://doi.org/10.1111/1468-036X.00056
12. Dittrich, L. O., & Srbek, P. (2020). Is Violation of the Random Walk Assumption an Exception or a Rule in Capital Markets? *Atlantic Economic Journal*, *48*(4), 491–501. https://doi.org/10.1007/s11293-020-09686-y
13. Dragotă, V., & Țilică, E. V. (2014). Market efficiency of the Post Communist East European stock markets. *Central European Journal of Operations Research*, *22*(2), 307–337. https://doi.org/10.1007/S10100-013-0315-6
14. Dragott, V., Stoian, A., Traian, D., Mitricc, E., & Bensafta, M. (n.d.). *THE DEVELOPMENT OF THE ROMANIAN CAPITAL MARKET: EVIDENCES ON INFORMATION EFFICIENCY*. http://ssrn.com/abstract=2191764https://ssrn.com/abstract=2191764Electroniccopyavailableat:http://ssrn.com/abstract=2191764
15. Enescu Student, A.-G. (n.d.). *ASSESSMENT OF DAY-OF-THE-WEEK EFFECT AND OTHER STOCK MARKET ANOMALIES: ROMANIAN EVIDENCE*. www.jseg.ro
16. Fama, E. F. (1965). The Behavior of Stock-Market Prices. In *Source: The Journal of Business* (Vol. 38, Issue 1). https://www.jstor.org/stable/2350752
17. Fama, E. F. (1970a). Efficient Capital Markets: A Review of Theory and Empirical Work. In *Source: The Journal of Finance* (Vol. 25, Issue 2).
18. Fama, E. F. (1970b). Efficient Capital Markets: A Review of Theory and Empirical Work. In *Source: The Journal of Finance* (Vol. 25, Issue 2).
19. Fama, E. F., Fisher, L., Jensen, M. C., & Roll, R. (1969). The Adjustment of Stock Prices to New Information. In *Review* (Vol. 10, Issue 1).
20. French, K. R. (1980). Stock returns and the weekend effect. *Journal of Financial Economics*, *8*(1), 55–69. https://doi.org/10.1016/0304-405X(80)90021-5
21. Heininen, P. (2008). Stock Market Efficiency In The Transition Economies Through The Lens Of Calendar Anomalies [Bookitem]. In *EACES 10th bi-annual conference Patterns of Transition and New Approaches to Comparative Economics, Moscow, Russia, 28-30 August, 2008*. Higher School of Economics.
22. KEIM, D. B., & STAMBAUGH, R. F. (1984). A Further Investigation of the Weekend Effect in Stock Returns. *The Journal of Finance*, *39*(3), 819–835. https://doi.org/10.1111/j.1540-6261.1984.tb03675.x
23. Mandelbrot', B. B. (n.d.). *STATISTICAL METHODOLOGY FOR NONPERIODIC CYCLES: FROM THE COVARIANCE TO R/S ANALYSIS*.
24. Mandelbrot, B. B. (1971). When Can Price be Arbitraged Efficiently? A Limit to the Validity of the Random Walk and Martingale Models. In *Source: The Review of Economics and Statistics* (Vol. 53, Issue 3). https://about.jstor.org/terms
25. Mandelbrot, B. B., & Hudson, R. L. (n.d.). *The (mis)Behavior of Markets A Fractal View of Risk, Ruin, and Rew ard*.
26. Patev, P., & Kanaryan, N. (n.d.). *Stock Market Volatility Changes in Central Europe Caused by Asian and Russian Financial Crises (Stock Market Volatility Changes in Central Europe) Stock Market Volatility Changes in Central Europe Caused by Asian and Russian Financial Crises Stock Market Volatility Changes in Central Europe Caused by Asian and Russian Financial Crises*.
27. Plastun, A., Sibande, X., Gupta, R., & Wohar, M. E. (2019). Rise and fall of calendar anomalies over a century. *North American Journal of Economics and Finance*, *49*, 181–205. https://doi.org/10.1016/j.najef.2019.04.011
28. Pleşoianu, A., Todea, A., & Căpuşan, R. (2012). The Informational Efficiency of the Romanian Stock Market: Evidence from Fractal Analysis. *Procedia Economics and Finance*, *3*, 111–118. https://doi.org/10.1016/s2212-5671(12)00128-1
29. ROGALSKI, R. J. (1984). New Findings Regarding Day-of-the-Week Returns over Trading and Non-Trading Periods: A Note. *The Journal of Finance*, *39*(5), 1603–1614. https://doi.org/10.1111/j.1540-6261.1984.tb04927.x
30. Shehadeh, A. A., & Zheng, M. (2023). Calendar anomalies in stock market returns: Evidence from Middle East countries. *International Review of Economics and Finance*, *88*, 962–980. https://doi.org/10.1016/j.iref.2023.07.013
31. Sidney S. Alexander. (n.d.). *Price Movements in Speculative Markets: Trends or Random Walks*.
32. Țilică, E. V., & Oprea, D. (2014). Seasonality in the Romanian Stock Market: The-day-of-the-Week Effect. *Procedia Economics and Finance*, *15*, 704–710. https://doi.org/10.1016/S2212-5671(14)00543-7