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BEHAVIOURAL FINANCE: TESTING THE EFFICIENT MARKET HYPOTHESIS ON THE BELGRADE STOCK EXCHANGE[1]

Olivera Mijailović*, Vule Mizdraković

Singidunum University,
Belgrade, Serbia

Abstract:
The goal of this paper is to highlight the limitations and reasons for the failure in modeling and materialization of scientific findings due to the assumption of rational behavior by investors. The confirmed inefficiency in the capital market affects investors in such a way that their decisions are not based on a proper evaluation of financial instruments. The results of the conducted empirical research disprove the hypothesis of traditional finance, which assumes rational decision-making. Therefore, to comprehend the process of investment decision-making, it is necessary to adopt the approach offered by behavioral finance, which incorporates a component of irrationality. The purpose is to analyze Belex15 yields and volatility with the aim of making effective investment decisions by applying and comparing the results of ARCH and GARCH models. These models are designed for time-series analysis, considering the observed instability of conditional variance. Using 2,517 daily logarithmic returns of Belex15, the E-GARCH model was selected, and the results suggest that investors must be cautious in their decision-making as the impact of negative shocks on yield volatility has a strong long-memory effect, making these investments highly risky, especially during unfavorable economic conditions.

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INTRODUCTION

One of the recommendations and conclusions drawn was that the efficient market hypothesis should be tested at the Belgrade stock exchange. The purpose of this paper is to examine the hypothesis of market efficiency in developing capital markets. The capital market is considered efficient if the prices of financial assets incorporate all available information and, accordingly, investors in the capital markets cannot achieve above-average returns.

1 This paper is the result of a short presentation and afterwards discussion related to a study on financial statements audit in the COVID-19 times, which commenced on International Scientific Conference FINIZ, held in Belgrade at the end of 2022.

*E-mail: olivera_kv@live.com

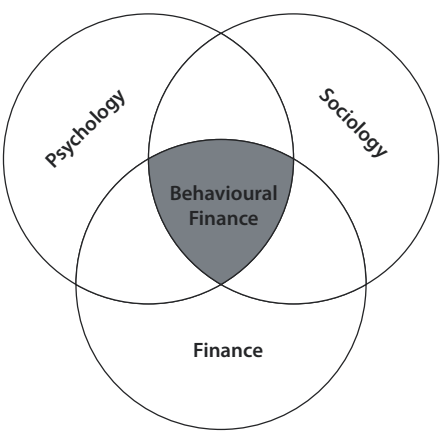
The weak form of efficiency makes it impossible to predict price movements in the future because it starts from the hypothesis of a random course of price movements and the absence of correlations between successive changes in their values. Through an econometric analysis of the index of the Belgrade Stock Exchange - Belex15, the paper tested whether the capital market of the Republic of Serbia fulfils the weak form of efficiency. To that end, this paper will analyse the trend of the logarithmic returns of the Belex15 market index to make effective financial decisions on investments using autoregressive conditional heteroskedasticity (ARCH) and generalized autoregressive conditional heteroskedasticity (GARCH) models, using the lowest values of information criteria. In the first part of the paper, the used data and research methodology of the Belex15 market index as an approximator of the RS capital market are described: examination of stationarity, heteroskedasticity, autocorrelation of returns, and the distribution of logarithmic returns of the distribution in relation to the normal distribution. The following part of the paper concerns the testing of different ARCH/GARCH models and the assessment of the proposed specification, as well as the statistical quality of the model. The last part summarizes the presented findings and gives specific recommendations to global investors.

THE INFLUENCE OF BEHAVIORAL FINANCE ON THE INVESTMENT DECISIONS

Irregularities observed in the market that are not in accordance with the standard economic model that encouraged the development of the behavioural economics, are most represented in the financial sector. Behavioural finance is the most developed area of behavioural economics. Unlike traditional finance that is based on the rationality of decision-making, behavioural finance introduces the irrationality component, which leads to the emergence of a new paradigm known as behavioural finance (Seth & Chowdary, 2017; Kumar & Chandel, 2018). Investors often depend on the rule of thumb in place of long and laborious mental calculations that may lead to poorer options and market friction (Arora & Chakraborty, 2021).

With the intention to make more efficient decisions on the financial market, it is necessary to get to the core of behavioural finance that combines cognitive psychological theories with conventional economy and finance (Sharna & Sarma, 2022). Behavioral finance in the interactive development with a multidiscipline approach dealing with psychology, economics, finance, and others (Andriamahery & Qamruzzaman, 2022). In the other words, starting point for defining behavioural finance is defining psychology, sociology and finance and looking at their relationship, Figure 1.

Figure 1. Interdisciplinarity of behavioural finance



Source: *(Virigineni & Rao, 2017, p. 449)*

It has already been pointed out that psychology is a science that includes the systematic study of the psychological life of humans and animals based on the scientific study of objective behaviour and direct experience. Sociology is a general science of society that studies the origin, development, organization types, structure, and dynamics of society, as well as individual social organizations and institutions (Trebješanin, 2018). Sociology is closely related to psychology, but it should be emphasized that they have a different angle of observation in the study of the same subject: sociology investigates the connection of certain social and psychological events, and psychology the subjective aspect of social phenomena. Finance is defined as the science of money management. They cover three main areas: investment, financing, and asset management planning (Van Horne & Wachowicz, 2014; Mankju & Tejlor, 2016).

Elements of psychology in behavioural finance: cognitive psychology, perception, heuristics, thinking and expectation. Cognitive psychology is an area of psychology focused on understanding and explaining psychological processes. Perception is the process of sensation, organization, and interpretation of stimuli with the aim of determining their meaning (Robbins & Judge, 2018). It is not only a simple and passive reflection of reality, but also involves connecting sensory data with previous experience, categorizing them, and giving them meaning. Heuristics is part of scientific methodology and represents the ability to find the truth or new facts and insights. Critical thinking is an opinion that is based on a systematic, impartial, and careful examination of facts, premises, evidence, and conclusions. Critical thinking is based on reason and facts and is independent of any authority. Expectation is cognitive-mental-motor attitude, an attitude of orientation towards what will come, which is anticipated based on previous experience (Trebješanin, 2018).

Behavioural finance brings psychology, sociology, and other research methods to the study of investment behaviour to explain how investors process information and take certain actions (Zhang & Zheng, 2015). Traditional financial paradigm explains financial decisions by assuming that markets and many of their participants and institutions are rational (Kamoune & Ibenrissoul, 2022). In the other words, behavioural finance analyse how psychology affects finance: how human behaviour affects asset price. The fact is that many of the fundamental models of modern finance are based on assumptions about the rationality of investors and efficient markets. The assumptions for rational decision-making are: the problem is clear and unambiguous; one, well-defined goal should be achieved; all alternatives and consequences are known; priorities are clear, permanent and stable; there are no time and cost restrictions (Robbins & Coulter, 2018). Rational investors are the basic prerequisite for efficiency. However, modern capital markets are exposed to constant changes and risk that lead to anomalies in the behaviour of market actors, and investors make their decisions in conditions of limited rationality.

It was pointed out that behavioural finance refers to decision-making regarding investment, financing, and asset management planning. Decision-making theories can be normative and descriptive (behavioural). Descriptive decision-making theories are concerned with describing the way decision-makers think, solve the problems they face, and the reasons why they decide on certain solutions. Descriptive theories of decision-making have their origins, to the greatest extent, in the field of experimental psychology. The task of descriptive decision-making theories is to describe events in a real decision-making situation, while avoiding giving any value judgements about the quality of the decision that was made. Among the many descriptive decision-making theories, the most important are: behavioural decision-making theory, social choice theory, expected utility theory, naturalistic decision-making theory and image theory (Takemura, 2014). Behavioural decision-making theories are based on the view that people have limited information processing abilities and that they lack the ability and motivation to perform the set of important calculations on which rational choice models are based (Sahu, Padhy, & Dhir, 2020). Behavioural economics has a wide range of applications.

Results of numerous research on the rationality of investment decision-making have shown that the following components affect this decision-making process: gender and income (Kumar & Goyal, 2016); age, profession and frequency of trading (Prosad, Kapoor, & Sengupta, 2015); portfolios of elder age groups and female investors achieve better performance, also when making investment decision male and female differ radically in disposition effect, (Kumar & Goyal, 2016); beliefs and preferences of the investors (Sahi, Arora, & Dhameja, 2013); personality traits (Durand, Koh, & Tan, 2013); sources of information (Tauni, Fang, & Iqbal, 2016); emotions (Mitroi & Oproiu, 2014; Shen, Najand, Dong, & He, 2017); extraversion (Oehler, Wendt, Wedlich, & Horn, 2018). Also, the perception of realized portfolio returns from the past affects individual and institutional trading and risk taking (Khan, Tan, & Chong, 2017). The research goes so far that even lunar cycles have been investigated in relation to investors' mood on stock exchange with excellent results (Chong & Hou, 2022). The study in Pakistan (Rashid, Tariq, & Rehman, 2021) examined the effects of behavioural biases on investment decision-making in the Karachi Stock Exchange. The results showed that investors' confidence, optimism, and rational expectations positively affect trading volume. The study provides valuable insights into the irrational behaviour of Pakistani investors. In this study Vasileiou (2020) examines the efficiency of the US stock markets during the COVID-19. The study shows a systemic factor, the health risk, was not always rationally incorporated in stock prices, that the market was not efficient during the COVID-19. The inefficiency is result of misappropriate from traditional finance models, such as the impact of fear. This study provides that the fear drives the S&P500 performance and using a GARCH model examined that the fear negatively influences the performance of the US stock market.

Bouteska and Regaing (2020) investigate the impacts of loss aversion and overconfidence on the performance of US-insured industrial and services companies. It was documented that the loss-aversion bias negatively affects the economic performance of companies for both sectors. In contrast, the findings suggest that overconfidence positively affects market performance of industrial firms but negatively affects market performance in service firms. Investors may tend to be more overconfident rather than more loss-averse. Gowri and Ram (2019) analyses impact of news on investor decision and explain how investor give attention to news only when it affects their portfolio or investment objective and strategies. Investor's decision making depends on degree of information penetration, information content, information influence, specific internal factors and generic external and on investors prevailing at those given circumstances.

TESTING THE EFFICIENT MARKET HYPOTHESIS ON THE EXAMPLE OF THE BELGRADE STOCK EXCHANGE

The term "efficient market hypothesis" was first mentioned in the work of the French mathematician Bachelier (1900) "Théorie de la speculation" and refers to the informational efficiency of the market, which measures the speed and accuracy of the market's reactivity to newly arrived information. The starting assumption is that all past, present, and discounted future events are incorporated into market prices, although they often have no direct connection with price changes (Cootner, 1964).

According to the efficient market hypothesis, the stock market is always perfect and efficient, and the stock price reflects all general information (Putri, Christiana, Kalsum, Widya, & Justianti, 2021), which enables investors in the financial market to achieve an average return. It is assumed that if the market does not predict fluctuations in the prices of financial assets, it estimates them with a certain probability, which enables a mathematical evaluation of that probability.

This assumption encouraged the analysis that preceded Einstein's work in the field of Brownian motion (Bernstein, 1992) and research in the field of financial economics from the beginning of the 1930s, which confirmed Bachelier's thesis that professional investors in the financial market do not have the opportunity to beat the market by achieving above-average returns. The high degree of competition on the more developed and efficient capital markets is reflected in the large number of economic transactors on the supply and demand side. Due to strong competition, prices get instantly adjusted to all information about past events, as well as to anticipated events in the near future. Therefore, the efficient market hypothesis is linked to the random walk hypothesis, according to which stock prices randomly move around the true intrinsic value. Research conducted from the 1930s to the 1950s confirmed that the stock returns of American companies follow a random walk model. In efficient markets, rational investors quickly notice and take advantage of non-random deviations of the market price from its intrinsic value and, analogous to the concept of perfect competition, with their behaviour they neutralize the predictability of the share price, which returns it to a state of equilibrium when the pressures of buying undervalued and selling overvalued shares disappear. Fama (1970) provided a theoretical advance by defining three forms of information efficiency: weak, semi-strong and strong forms. Tests examining the weak form of capital market efficiency analyse historical prices, while testing stronger forms involves examining all publicly available information (semi-strong form), as well as information available exclusively to selected individuals (strong form).

Capital market efficiency plays a key role for investors, managers, and the overall economy. A financial market that provides a valid estimate of the buying/selling price of stocks attracts investors to trade more. In addition, the decision-making process for company managers is made easier. Namely, the goal of management decisions is to maximize shareholder wealth. It is in the interest of the company's management that, through a positive capital gain of the share on the capital market, the result of the implemented decision becomes visible to the existing shareholders as well as to the wider investment public. Finally, efficient capital markets are essential to the allocation of resources in the economy as a whole. The allocative function of the capital market is provided by properly determined prices that fully reflect all available information. In this way, it is easier for companies to make production and investment decisions. In addition, correctly determined market prices of financial material help investors in the formation of investment portfolios. In addition to the allocative role, efficient capital markets have a stimulating effect on savings and the growth of the economy as a whole.

Further on in the paper, the assumption of a weak form of efficiency on the domestic capital market will be examined, which excludes the possibility of predicting the future movement of the Belgrade Stock Exchange index. Given this fact, participants in a market where the hypothesis of weak efficiency is satisfied are not able to achieve abnormal returns relying only on historical data on market price movements.

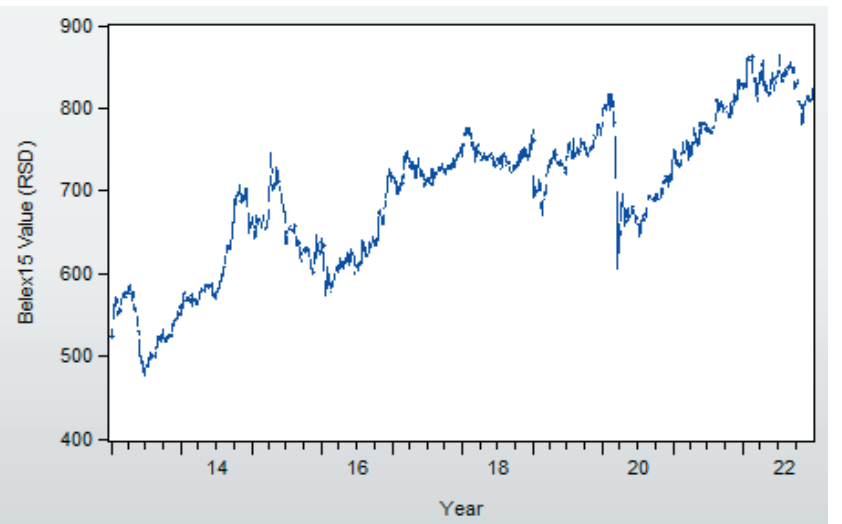
RESEARCH METHODOLOGY AND RESULTS

In the empirical part of the paper, Belex15 was used to approximate the movement of the domestic capital market. The index values were taken from the Belgrade Stock Exchange website (www.belex.rs). The research was conducted on the data on the daily values of Belex15 for the period from 12/31/2012 until 12/29/2022 (a total of 2,518 observations), using the EViews software package. An increase in the value of the index represents a capital gain, while a decrease in value represents a capital loss.

The paper will test the hypothesis of traditional finance on the efficiency of the market. In the case of market inefficiency, the approach offered by behavioural finance, which introduces a component of irrationality into its paradigm, is recommended for understanding the investment decision-making process. The market efficiency hypothesis was tested by testing:

1. The weak form of the efficiency hypothesis of the capital market of the Republic of Serbia was tested using econometric tests of the random walk hypothesis, which include: the unit root test and the test for the presence of autocorrelation of model residuals. Testing the hypothesis about the stationarity of the time series of the market index, Belex15, was carried out using the ADF unit root test;
2. The testing of the normal Gauss distribution of the empirical distribution of the logarithmic returns of Belex15 was performed using the histogram of the frequency of the distribution of logarithmic returns, descriptive statistics and the Jarque-Bera test;
3. Testing the hypothesis that there is no residual heteroskedasticity in the OLS regression residuals was conducted using the ARCH test;
4. Testing the hypothesis that there is no autoregressive structure of variability in the residuals of the OLS regression was tested with the Breusch-Godfrey Serial Correlation LM test, autocorrelation correlogram, partial autocorrelation and Q statistics (Ljung-Box Q-test) of the residuals of the daily rate of logarithmic returns of Belex15.

Figure 2. Movement of the Belex15 index value in the period from January 31, 2012 until December 29, 2022 (2,518 daily observations)



Source: *Authors' data*

Time series stationarity test

Testing the stationarity of the time series for the Belex15: Testing whether the statistical properties of the time series change over time, i.e., whether the time series is stationary or has a unit root, was carried out using the Augmented Dickey-Fuller test ADF) which examines the stationarity of a time series data. Schwarz's information criterion (SIC criterion) was used when choosing the number of lags. If the statistical properties of the time series do not change over time, the time series is stationary. Stationarity is the property of a time series whose movement over time follows a fixed pattern in terms of invariance of the mean value and variance. Stationarity rejects the random walk hypothesis of returns, and this predictability of returns rejects the weak form of the capital market efficiency hypothesis. Conversely, if the movement parameters of the time series are a function of a moment in time, then the time series is non-stationary, and the returns follow a random walk. The unpredictability of returns confirms the weak form of the capital market efficiency hypothesis and the impossibility of achieving above-average returns.

The stationarity of the Belex15 time series was tested using all three forms of ADF: a constant as a deterministic component, a constant and trend as deterministic components and no deterministic component used. The null hypothesis was tested:

H0: The time series is not a stationary variable, that is, there is a unit root in the analysed time series, in contrast to the alternative hypothesis:

H1: The time series is a stationary variable, that is, it does not have a unit root.

Table 1. Results of the ADF unit root test of the Belex15 index values

Augmented Dickey-Fuller Test		**t-Statistic**	**p***
ADF with a constant		**-1.845142**	**0.3588**
Test critical values:	1% level		
	5% level	-2.862490	
	10% level	-2.567321	
ADF with a constant and linear trend		**-3.358800**	**0.0573**
Test critical values:	1% level	-3.961696	
	5% level	-3.411596	
	10% level	-3.427667	
ADF without a constant or linear trend		**0.779048**	**0.8814**
Test critical values:	1% level	-2.565883	
	5% level	-1.940950	
	10% level	-1.616615	

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

Source: *Author's calculations*

All three forms of the ADF unit root test in Table 1 have a p-value greater than 5%, and the null hypothesis can be confirmed: The time series of the Belex15 market index value is not a stationary variable because it has a unit root. The null hypothesis was also confirmed by comparing the absolute value of the t-statistics, which are smaller than the corresponding critical values for 99%, 95% and 90% reliability: The value of the Belex15 index is not a stationary variable. In order to transform a stationary into a non-stationary variable, the logarithmic values were differentiated and the obtained logarithmic returns were used to carry out the ADF unit root test on the thus obtained differentiated data. The first difference of the logarithmic value of Belex15 represents the daily rate of return.

Table 2. Results of the ADF unit root test of the first difference of the logarithmic return of the Belex15 index.

Augmented Dickey-Fuller Test		**t-Statistic**	**p***
ADF with a constant		**-21.26894**	**0.0000**
Test critical values:	1% level	-3.432759	
	5% level	-2.862490	
	10% level	-2.567321	
ADF with a constant and a trend		**-21.26747**	**0.0000**
Test critical values:	1% level	-3.961696	
	5% level	-3.411596	
	10% level	-3.127667	
ADF with a constant and a trend		**-21.24317**	**0.0000**
Test critical values:	1% level	-2.565883	
	5% level	-1.940950	
	10% level	-1.616615	

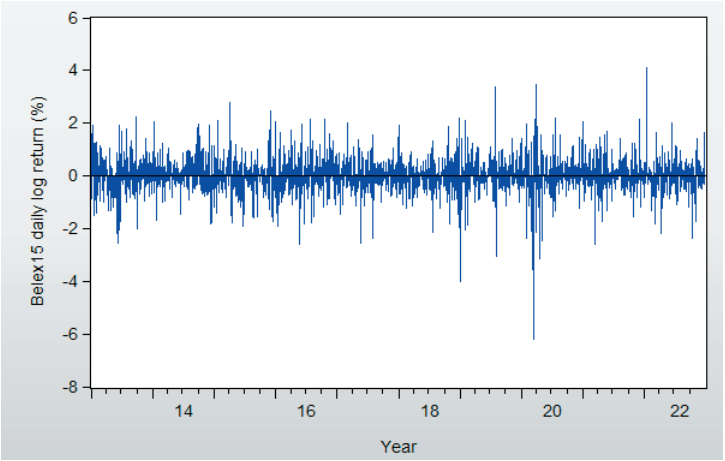
* MacKinnon (1996) one-sided p-values.
Source: *Author's calculations*

Based on the data in Table 2, it is concluded that the first difference of the logarithmic data in all three forms of the ADF test has a p-value less than 5%, the null hypothesis is disproved, and the alternative is confirmed: The first difference of the Belex15 returns has transformed the variable into a stationary time series of 2,517 observations without unit root. The null hypothesis has also been disproved by comparing the absolute values of the t-statistics, which are higher than the corresponding critical values for 99%, 95% and 90% reliability. Further on in the paper, the testing of heteroskedasticity and autocorrelation of residuals on the Belex15 logarithmic returns has been carried out.

Examining the normal Gaussian distribution of the empirical distribution of the Belex15 logarithmic returns

High oscillations in the movement of the Belex15 daily return rates are shown in Figure 3. The presence of many extreme values can be noticed.

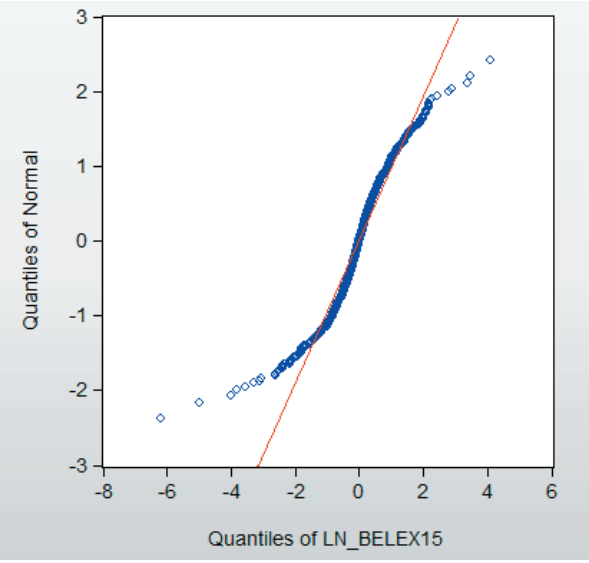
Figure 3. Movement of the Belex15 logarithmic returns in the period from January 31, 2012. until December 29, 2022 (2,517 daily observations)



Source: *Authors' data*

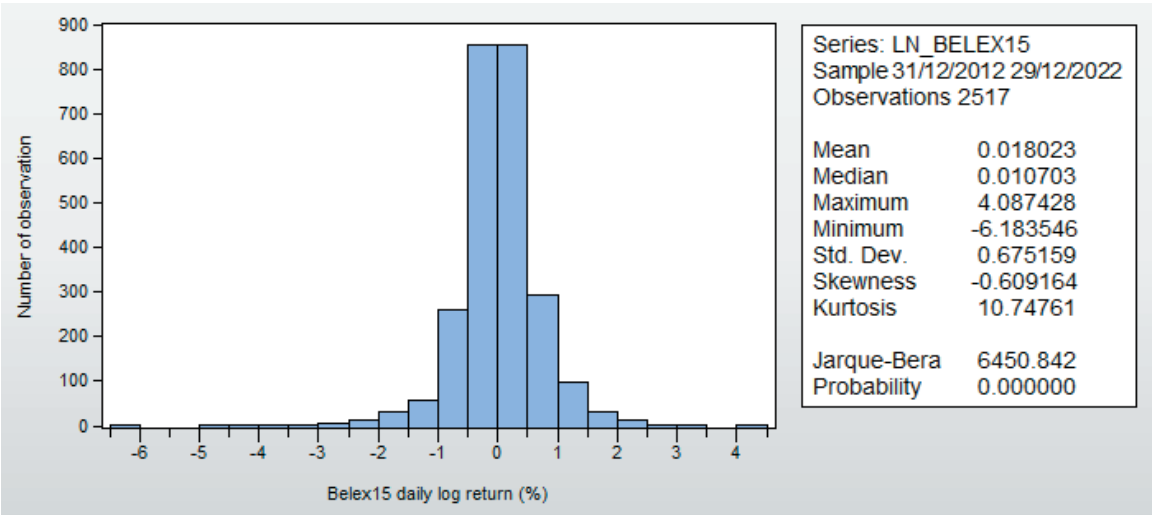
Using the QQ diagram (quantile-quantile plot), it has been tested to what extent the empirical distribution deviates from the theoretical distribution function by comparing standardized values, where the points on the graph are on the line that shows what the direction would be in case the sample originated from the assumed normal Gaussian distributions.

Figure 4. Q-Q diagram of the Belex15 logarithmic returns in relation to the theoretically assumed normal Gaussian distribution in the period from January 31, 2012 until December 29, 2022. (2,517 daily observations)



Source: *Authors' data*

Figure 5. Histogram of the distribution frequency of the Belex15 logarithmic returns in the period from January 31, 2012 until December 29, 2022.



***Source**: Authors' data*

Descriptive statistics of the return series show that the mean is 0.018023%, the median is 0.010703, and the standard deviation is 0.675159%. The maximum realized return value was 4.087428%, while the largest realized loss was -6.183546%. The asymmetry of the empirical distribution of returns represents a unique measure of risk, that is, the probability of the appearance of high values, either positive or negative, while the flattening indicates the probability of unexpected positive or negative movements of high intensity returns. In other words, investors prefer positively asymmetric distributions in relation to negatively asymmetric distributions, and distributions that do not have extreme values, that is, a fat-tailed distribution.

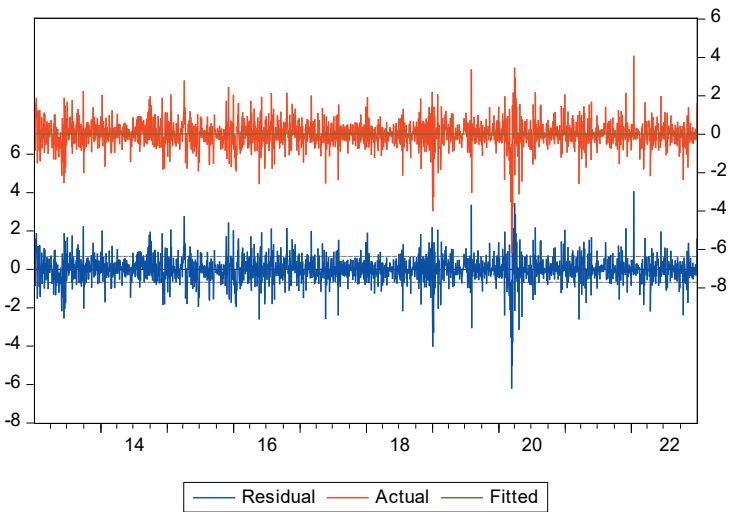
The coefficient of asymmetry or skewness is -0.609164: a negatively asymmetric empirical distribution indicates a longer left end of the distribution, and a higher probability of achieving high negative values compared to positive values. Since the mean value of the logarithmic return is less than the median, the return distribution is asymmetric to the left: the existence of extremely large measurements in the left section of the distribution relative to the right section (McClave, Benson, & Sincich, 2018), the existence of a greater number of extreme losses relative to the number of extreme gains. The flatness coefficient or kurtosis for the normal Laplace-Gaussian distribution a_4=3, and this value is used to determine the flatness of empirical distributions. If the flatness value of the empirical distribution is greater than 3, the distribution has an elongated shape (*Leptokurtic* distribution), and if it is less than 3, the distribution is flattened (*Platykurtic* distributions). The empirical distribution of logarithmic returns has a flattening coefficient value greater than 3 and equals 10.74761: based on the obtained coefficient, it can be concluded that the curve of the empirical distribution is more elongated compared to the normal distribution, i.e., that the probability of the occurrence of returns further from the mean value at the ends of the distribution is higher than the normal distribution assumes. In other words, the empirical distribution has a fat tail. The presence of extreme values determines the observed leptokurtosis.

The value of the Jarque-Bera coefficient is 6450.842 with a p-value of 0.000000 which is less than 5%, so we can disprove the null hypothesis and confirm the alternative: the time series of the Belex15 return rate is not normally distributed. The critical value of the $\chi 2$ distribution for the 5% significance level is 5.99, and for the 1% significance level it is 9.21. With a probability of 95 and 99%, the null hypothesis of the existence of a normal distribution of return rates is disproved because the value of the JB statistic is greater than 5.99 and 9.21.

Examination of heteroskedasticity of OLS regression residuals

The least squares model assumes that the variance of the random error has a constant value (homoskedasticity). However, volatilities are not constant over time (heteroskedasticity). Low and high intensity return fluctuations are grouped into clusters. In addition, there is also a leverage effect in financial time series: changes in the price of financial assets are negatively correlated with changes in volatility. The leverage effect explains the fact that volatility increases to a greater extent following a large price decline than following a price increase that is of the same absolute value as the price decline. For financial asset returns, a negative shock has a stronger effect on volatility compared to a positive shock of the same intensity. In this paper, the hypothesis about heteroskedasticity of the classic OLS model residuals was tested with the ARCH (Autoregressive Conditional Heteroskedasticity) test. Figure 6 shows the grouping of volatility in the residuals, i.e., the heteroskedasticity feature.

Figure 6. Residual movements of the Belex15 daily return rate



***Source**: Authors' data*

Figure 6 confirms variable volatility in time, i.e., heteroskedasticity, when the volatility of the time series is grouped in time and forms clusters, and small fluctuations in volatility are often followed by small fluctuations, while large fluctuations in volatility are often followed by large fluctuations.

Table 3. Results of the daily return rate residual heteroskedasticity test

F-statistic	53.84169	Prob. F(1,2514)	0.0000
Obs*R-squared	52.75469	Prob. Chi-Square(1)	**0.0000**

Heteroskedasticity Test: ARCH
***Source:** Authors' calculations*

In order to confirm the existence of heteroskedasticity, the null hypothesis was tested:

H0: There is no ARCH effect in the OLS regression residuals, contrary to the alternative

H1: There is an ARCH effect in the OLS regression residuals.

Based on Table 3, the probability value *p*, χ^2 is ((Prob. Chi-Square(1)) less than 5%, so we disprove the null hypothesis and confirm the alternative that is about the existence of an ARCH structure in the residuals of the OLS regression of the logarithmic returns of the Belex15 time series.

Examining the autoregressive structure

The autocorrelation of logarithmic returns does not have a value of zero even at large lags, which confirms the existence of time dependence in the long term. In the paper, the hypothesis of the presence of an autocorrelation structure will be tested with the autocorrelogram and Q statistics.

H0: In the residuals of the OLS regression, there is no autoregressive structure of variability, as opposed to an alternative one

H1: There is an autoregressive structure in the OLS regression residuals.

Table 4. Results of the autoregressive structure test of the residuals of the daily rate of return Breusch-Godfrey Serial Correlation LM Test

F-statistic	9.380289	Prob. F(2,2514)	0.0000
Obs*R-squared	18.64384	Prob. Chi-Square(2)	**0.0001**

Source: *Authors' calculations*

Based on Table 4, the probability value *p*, χ^2 is (Prob. Chi-Square(2)) less than 5%, so we disprove the null hypothesis and confirm the alternative one about the existence of an autoregressive structure in the residuals of the OLS regression of the logarithmic returns of the Belex15 time series. After the above conclusion, a graphical analysis of the ordinary and partial correlogram (AC and PAC) of the residuals of the OLS model was carried out, and the p values of the Q-statistic were analysed on all lags. On all lags, *p* values are less than 5%, based on which the null hypothesis is disproved and the alternative hypothesis that there is an autoregressive structure in the residuals of the logarithmic returns of Belex15 is thus confirmed.

Figure 6. Correlogram of autocorrelation, partial autocorrelation and the value of the Q statistic of the residuals of the daily rate of return Belex15

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.047	0.047	5.4832	0.019
		2	0.074	0.072	19.401	0.000
		3	0.055	0.049	27.048	0.000
		4	0.081	0.072	43.709	0.000
		5	0.012	-0.001	44.090	0.000
		6	0.009	-0.005	44.283	0.000
		7	0.001	-0.007	44.288	0.000
		8	0.035	0.029	47.312	0.000
		9	-0.032	-0.035	49.887	0.000
		10	-0.006	-0.007	49.968	0.000
		11	-0.020	-0.018	51.011	0.000
		12	-0.045	-0.045	56.157	0.000
		13	-0.009	0.002	56.376	0.000
		14	-0.027	-0.018	58.262	0.000
		15	0.008	0.018	58.436	0.000
		16	-0.018	-0.010	59.263	0.000
		17	-0.043	-0.039	63.918	0.000
		18	0.020	0.027	64.903	0.000
		19	0.005	0.009	64.972	0.000
		20	-0.021	-0.017	66.053	0.000
		21	-0.010	-0.008	66.293	0.000
		22	0.008	0.008	66.464	0.000
		23	-0.006	-0.009	66.544	0.000
		24	0.032	0.035	69.108	0.000
		25	-0.019	-0.020	70.067	0.000
		26	0.031	0.023	72.561	0.000
		27	0.038	0.038	76.167	0.000
		28	0.027	0.017	78.051	0.000
		29	-0.005	-0.015	78.125	0.000
		30	0.037	0.028	81.598	0.000

Source: *Authors' data*

The value of the Ljung-Box Q-statistic (Ljung & Box, 1978) for the order of the correlation coefficient 30 shown in the correlogram (Figure 6) is 81.598 with the value Prob = 0.000 which is less than 5%, the null hypothesis is disproved, and the alternative is confirmed: the residuals have serial autocorrelation property. The tabular value of the Ljung-Box Q-test for the order of the correlation coefficient 30 is: $\chi^2 30, 0.05 = 43.773$ and is less than the obtained value (81.598) and based on the results of the Q-test, the null hypothesis is disproved, and the alternative hypothesis is confirmed: there is an autocorrelation of order 30 in the model.

Based on the conducted empirical research, the hypothesis about an efficient market is disproved, i.e., that the prices of domestic stocks do not give adequate signals to investors (who seek to achieve capital gains or dividend yield), or to managers (who make decisions to maximize value for shareholders) through the changes in stock prices on the capital market. The emerging capital market of the Republic of Serbia is considered, where the participants are poorly informed due to market non-transparency and, accordingly, are more prone to irrational investment decisions. The domestic market, like other emerging capital markets, has a low volume of trading, high transaction costs and a problem with illiquidity.

Additionally, there is an issue with asynchronous trading, weak institutional development compared to developed markets, and in some cases be the object of manipulation by large investors. For these reasons, the empirical research conducted in the paper is limited to testing the weak form of the efficient market hypothesis.

ARCH/GARCH models

Based on the conducted econometric tests, which confirmed that the logarithmic return of the Belex15 index is non-stationary (the movement of the Belex15 value over time does not follow a fixed pattern, the mean value and variance are not non-changing variables; autocorrelation (long-term dependence in the data: the values of the logarithmic returns are different from zero even on large lags, which shows the presence of time-dependent dependence in the long term); heteroskedasticity and leptokurtosis (the distribution function of financial asset returns has "heavier" tails and a higher probability of occurrence of extreme values compared to the normal Gaussian distribution). The presence of heteroskedasticity indicates that the variances of random errors are not equal, i.e., volatility is not constant in time, there is a problem of heteroskedasticity. In the next part of the paper, the specification that models' heteroskedasticity, i.e., the identified unequal conditional variances of returns will be applied: ARCH (AutoRegressive Conditional Heteroskedasticity) and GARCH (Generalized AutoRegressive Conditional Heteroskedasticity).

Testing of ARCH/GARCH models and evaluation of the proposed specification

Using the lowest value of Akaike information criterion - AIC, Schwartz information criterion - SIC and Hannan–Quinn information criterion - HQC, the paper will propose an optimal ARCH/GARCH model.

Table 5. Information criteria of different ARCH and GARCH models

	ARCH	GARCH (1,1)	T-GARCH	E-GARCH
AIC	1.890228	1.887800	1.888188	1.885801
SIC	1.906444	1.897067	1.899771	1.897384
HQC	1.896113	1.891163	1.892392	1.890005

Source: *Authors' calculations*

The asymmetric E-GARCH model has the lowest AIC, SIC and HQC values.

Table 6. Specification of the E-GARCH model (using E-Views software)

Dependent Variable: LN_BELEX15				
Method: ML - ARCH (Marquardt) - Normal distribution				
Sample (adjusted): 3/01/2013 29/12/2022				
Included observations: 2517 after adjustments				
Convergence achieved after 15 iterations				
Presample variance: backcast (parameter = 0.7)				
LOG(GARCH) = C(2) + C(3)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(4)				
*RESID(-1)/@SQRT(GARCH(-1)) + C(5)*LOG(GARCH(-1))				
Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	0.022311	0.010950	2.037519	0.0416
Variance Equation				
C(2)	-0.234132	0.015286	-15.31705	0.0000
C(3)	0.224427	0.015012	14.94989	0.0000
C(4)	-0.016996	0.009647	-1.761879	0.0081
C(5)	0.922553	0.007253	127.2014	0.0000
R-squared	-0.000040	Mean dependent var		0.018023
Adjusted R-squared	-0.000040	S.D. dependent var		0.675159
S.E. of regression	0.675172	Akaike info criterion		1.885801
Sum squared resid	1146.937	Schwarz criterion		1.897384
Log likelihood	-2368.281	Hannan-Quinn criter.		1.890005

Source: *Authors' calculations*

The asymmetric E-GARCH model has a negative coefficient C(4) -0.016996 and is statistically significant, which confirms the presence of the leverage effect: changes in the price of financial assets show a negative correlation with changes in volatility. The leverage effect explains the tendency of volatility to rise more following a large price decline than following a price increase of the same absolute value. For financial asset returns, a negative shock has a greater impact on volatility than a positive shock of the same intensity.

Evaluation of the statistical quality of the E-GARCH model parameterization

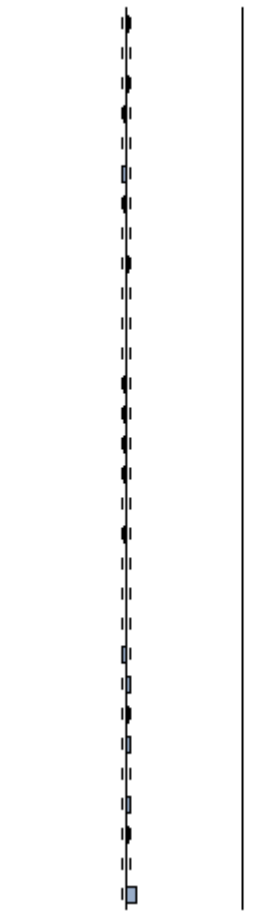
In order to assess the statistical quality of the model, it is necessary to test: a) heteroskedasticity; b) serial correlation and c) normal distribution of model residuals.

F-statistic	0.502312	Prob. F(1,2514)	0.4786
Obs*R-squared	0.502612	**Prob. Chi-Square(1)**	**0.4784**

Heteroskedasticity Test: ARCH
Source: *Authors' calculations*

The value of Prob. Chi-Square(1) is 0.4784 and is greater than the value of 5%, so the null hypothesis of the absence of ARCH effect in the residuals of the proposed model is accepted.

Figure 7. Correlogram of autocorrelation, partial autocorrelation and the value of the Q statistic of the residuals of proposed E-GARCH model

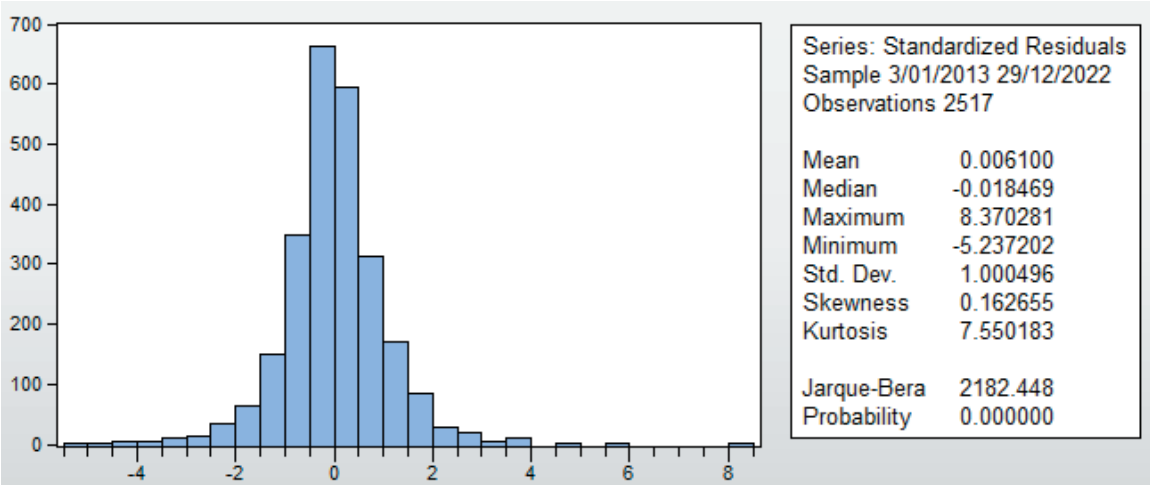


Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.014	0.014	0.4971	0.481
		2	0.003	0.002	0.5135	0.774
		3	0.012	0.012	0.8953	0.827
		4	-0.022	-0.022	2.0835	0.720
		5	0.005	0.006	2.1592	0.827
		6	-0.030	-0.030	4.3934	0.624
		7	-0.021	-0.020	5.5063	0.598
		8	0.002	0.002	5.5160	0.701
		9	0.013	0.014	5.9255	0.747
		10	-0.004	-0.005	5.9704	0.818
		11	0.004	0.004	6.0158	0.872
		12	0.002	0.002	6.0314	0.914
		13	-0.023	-0.024	7.3925	0.881
		14	-0.014	-0.015	7.9211	0.893
		15	-0.010	-0.008	8.1579	0.917
		16	-0.023	-0.021	9.4418	0.894
		17	-0.008	-0.008	9.6081	0.919
		18	-0.012	-0.011	9.9528	0.933
		19	0.000	-0.000	9.9529	0.954
		20	0.008	0.005	10.112	0.966
		21	0.007	0.006	10.249	0.975
		22	-0.026	-0.028	12.011	0.957
		23	0.035	0.034	15.068	0.892
		24	0.010	0.008	15.302	0.912
		25	0.028	0.029	17.277	0.871
		26	0.005	0.002	17.340	0.898
		27	0.028	0.030	19.284	0.859
		28	0.021	0.017	20.374	0.850
		29	0.000	0.000	20.374	0.881
		30	0.090	0.091	41.028	0.086

Source: *Authors' data*

The analysis of the ordinary and partial correlogram of the residuals indicates that the p-values of the Q-statistics on all lags are greater than 5%, and the null hypothesis that there is no autocorrelation in the residuals of the model is accepted. The Ljung-Box Q-statistics value for the order of the correlation coefficient 30 on the obtained correlogram is 41.028 higher than the table value, and the Prob* value ($p = 0.086$) is higher than 5%, the null hypothesis is also accepted from this aspect: in the residuals of the proposed there is no autoregressive structure in the model.

Figure 8. Histogram of the distribution frequency of the residuals of proposed E-GARCH model



Source: *Authors' data*

Hypothesis testing of the normal distribution of the residuals of the model shows that the value of JB statistics is 2182.448, while p = 0.0000 is less than 5%, the null is rejected, the alternative is accepted: the residuals of the proposed model are not normally distributed.

The absence of heteroskedasticity and serial correlation of the residuals of the asymmetric E-GARCH model are two of the three confirmed statistical qualities of the model. Since the two most significant features are covered by the model, the model is considered valid and applicable in the absence of a normal distribution. The results of the study conducted in this paper are in agreement with the results of the study conducted in five developing countries: SOFIX (Bulgaria), BUX (Czech Republic), PX (Hungary), WIG (Poland), and XU100 (Turkey) (Ugurlu, Thalassinos, & Muratoglu, 2014): the results have shown that strong GARCH effects exist in all markets except SOFIX; volatility shocks are quite persistent and the impact of old news on volatility is significant; bad news increases volatility and leverage effect in returns exist in the markets. Even in the capital market of the Republic of China, the examination of the Shanghai Composite Index and the Shenzhen Component Index based on the GARCH model showed that the GARCH-type models can be applied and reflect the volatility change with high accuracy (Wang, Xiang, Lei, & Zhou, 2022).

The research conducted at Indian stock market investigate the existence of volatility-based anomalies in Indian stock market. The study has employed various ARCH family models, GARCH, E-GARCH and component GARCH (CGARCH) to appraise assorted nature of volatility patterns. The results reveal the existence of stock market inefficiency due to volatility anomaly. The research outcomes verify the persistence of volatility in long and short run. The empirical evidence assists in acknowledging the degree of subsistence of anomalies and biases in market to comprehend the level of rationality of investors in diverse market situations (Siddiqui & Narula, 2017). In a study that examined the stock market volatility of ten emerging capital markets: India, China, Indonesia, Sri Lanka, Pakistan, Russia, Brazil, South Korea, Mexico, and Hong Kong, it found an autoregressive conditional heteroskedastic trend, shocks persist for a long time in returns, bad news has a greater impact on stock volatility than good news. Volatility models derived from the GARCH equation provide accurate forecasts and it was found that asymmetric information affected all observed markets (Sanyal & Gahan, 2016).

Results of empirical analysis presented in this paper are consistent with most studies carried out on emerging markets about relationship between stock returns and volatility. In this paper, we find that movements on Belgrade Stock Exchange seem to take a similar trajectory as on the other emerging markets.

The main restriction of the univariate GARCH models employed in analyzed empirical studies in emerging capital markets and in this study has obstacle describing the volatility spillover effect among financial markets and does not completely examine entire financial ambience. Subsequently, the further studies should create a multivariate GARCH model to test the total financial system.

CONCLUSION

The paper tested the Efficient Market Hypothesis, which represents the applied concept of the wider theory of rational expectations of investors, to show that the Efficient Market Hypothesis, i.e., the existence of inefficiency affects investors by their not basing their investment decisions on properly valued financial instruments. The specific conditions of the domestic capital market, as well as other poorly developed capital markets, refer to a small number of financial asset transactions, high transaction costs and low liquidity, making the practice of market manipulation more common. Poorly informed domestic investors often make irrational investment decisions due to the lack of transparency in publishing the plans of the company whose shares they invest in. This is precisely the connection in which behavioural finance finds its full application. In the paper, the hypothesis about the stationarity of the time series of the Belgrade Stock Exchange Belex15 market index was disproved by the ADF unit root test. The hypothesis of a normal Gauss distribution of the empirical distribution of the Belex15 logarithmic returns was disproved using the histogram of the distribution frequency of logarithmic returns and descriptive statistics, as well as the Jarque-Bera test. The hypothesis that there is no residual heteroskedasticity in the OLS regression residuals was disproved using the ARCH test. The hypothesis that there is no autoregressive structure of variability in the OLS regression residuals was disproved by the Breusch-Godfrey Serial Correlation LM test, autocorrelation correlogram, partial autocorrelation and Q statistics (Ljung-Box Q-test) of the residuals of the daily rate of the Belex15 logarithmic returns. The results of the conducted empirical analysis disproved the hypothesis of traditional finance, which assumes rational decision-making. Therefore, to understand the investment decision-making process, it is necessary to use the approach offered by behavioural finance, since it introduces the component of irrationality. By observing economics as a scientific discipline that deals with the study of rules of behaviour and economic laws in economic activities, one loses sight of the entirety of life's reality and the problem of discerning the meaning and purpose of the life process and life activities, both at the individual level and at the level of groups, subgroups, and communities. This paper and opinions here given do not diminish the importance of such a narrowly understood economics but give the perspective of its connection with the matrix form of life manifestation and the possibility of synthesizing previous scientific knowledge along the lines of the overall purposefulness of life activities. Life is a complex energy field and wave-particle structure in which the part is in the whole and the whole in the part. Injustice to someone is transmitted to the whole system and is a destructive process of decomposition. This paper can be seen as a small contribution to the creation of the quantum economics and the understanding of the basic knowledge flows that offer solutions to today's intractable problems. Economic energy is a manifest form of life energy that regulates the proper distribution of material goods and their proper use for the sake of harmonized and balanced development of the individual, local and wider community and society while preserving and improving the natural environment. Behavioural economics, which emerged from a symbiosis of economics and psychology, may be considered another example of a powerful methodological trend in the cross-disciplinary social studies known as ‘economic imperialism.’

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BIHEVIORALNE FINANSIJE: TESTIRANJE HIPOTEZE EFIKASNOG TRŽIŠTA NA BEOGRADSKOJ BERZI

Rezime:

Cilj ovog rada je da ukaže na ograničenja i razloge neuspeha u modelovanju i konkretizaciji naučnih saznanja zbog pretpostavke o racionalnom ponašanju investitora. Potvrđena neefikasnosti na tržištu kapitala na investitore utiče tako što odluke ne zasnivaju na valjano valorizovanim finansijskim instrumentima. Rezultati sprovedenog empirijskog istraživanja opovrgle su hipotezu tradicionalnih finansija koje se zasnivaju na pretpostavci o racionalnom donošenju odluka. Stoga, za razumevanje procesa investicionog odlučivanja neophodno je koristiti pristup koji nude bihevioralne finansije budući da uvode komponentu iracionalnosti. Svrha je sprovođenje analize prinosa i volatilnosti trzišnog indeksa Belex15 u cilju donošenja efikasnih investicionih odluka, primenom i upoređivanjem rezultata ARCH i GARCH modela. Modeli su namenjeni za analizu vremenskih serija koje poseduju nestabilnost uslovne varijanse. Obuhvatajući 2.517 logaritmovanih prinosa Belex15, odabran je E-GARCH model, a rezultati sugerišu da investitori moraju biti oprezni u donošenju odluka jer uticaj negativnih šokova na volatilnost prinosa ima snažan dugotrajan efekat memorije, što ove investicije čini veoma rizičnim, posebno u nepovoljnim ekonomskim okolnostima.

Ključne reči:
bihevioralne finansije,
(i)racionalna očekivanja,
Hipoteza efikasnog tržišta,
berza.