Testing the Weak Form of Efficiency in Moscow Exchange

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Abstract: The existence of weak-form price efficiency at the Moscow Exchange was examined for the period from the 3rd of January, 2005, till the 10th of January, 2019 with reference to daily, weekly and monthly time-series of returns for the Moscow Exchange stock index (MOEX). Parametric test approaches, namely, the ADF Unit Root Test and the autocorrelation test, as well as non-parametric tests, namely, the PP Unit Root test, the Runs test and the BDS Non-linear independence test, were applied to test the weak-form efficiency hypothesis for the Moscow Exchange stock index. The test results provide sufficient evidence to reject the weak-form efficiency hypothesis for the Moscow Exchange. The ADF and PP tests showed that the daily, weekly and monthly return variability is stationary. The BDS test reveals the presence of a non-linear correlation within daily, weekly and monthly stock index returns at the Moscow Exchange, which suggests irrational patterns of investment behavior from many investors in this market. The Runs test indicates that the investors are underestimating returns at the Moscow Exchange when new information arrives on the market. This study suggests that using technical and fundamental analyses would lead participants to profitable trading rules

Keywords: random walk hypothesis; efficient markets hypothesis; the Russian stock market; MOEX index; variability of stock returns

1. Introduction

The studies of Fama (1963, 1965a, 1965b), and Samuelson (1965) highlighted the importance of the financial market efficiency concept to researchers and analysts alike when they proved the existence of price efficiency in that period for the U.S. markets. At that time, the efficiency concept was limited to proving the existence of price efficiency, which has been categorized by Fama (1970) into the three levels: the weak form of efficiency, the semi-strong form of efficiency, and the strong form of efficiency.

The emergence of the concept of price efficiency has led to a major shift in the science of financial markets, and many pricing models have been built based on the hypothesis of price efficiency, including the capital asset pricing model (CAPM), and multi-factor pricing models such as Fama and French (1992), Carhart (1997), Fung and Hsieh (1997). Investment portfolio strategies reliant on a level of financial market efficiency, and a lot of stock price deviation studies depend on assuming the weak-form efficiency hypothesis as well.

The concept of market efficiency has developed and now we can distinguish between the three types of financial market efficiency: the operational efficiency, the allocation efficiency, the price efficiency, and the perfect efficiency (which means the market achieving all the previous efficiency types). The current study is limited to testing the weak-form efficiency as it is the cornerstone for starting studies on the other types of efficiency, e.g. see Altamimi (2012).

The importance of market efficiency lies in its impact on the financial system of a country because it reduces the systemic risks at the financial market as it increases the transparency of dealing in the market, thus reducing the level of price fluctuations and making the market attractive to investors.

The movement of invested capital in the global market takes into account the specifics of national stock markets and, above all, investment strategies are based on an analysis of the effectiveness of these markets. Therefore, testing the weak-form efficiency for the Moscow Exchange is important for helping investors in this market choose a proper investment strategy.

It should be noted that efficiency studies for the Moscow Exchange haven't been conducted previously by using the Brock, Dechert and Scheinkman (BDS) test of non-linear correlation and for a period of this length, which increases the accuracy of the current study results.

There is a possibility of achieving abnormal returns in markets that are not price-efficient. After reviewing several studies performed on the Moscow Exchange efficiency which were shown in Table 1, the researchers were unable to determine whether the market is weak-form efficient or not.

The time horizon which covers 14 years lends a greater credibility to the results of the current research from a statistical point of view than its predecessors, as none of the previous studies have surveyed a time horizon of this length.

The current study argues that the Moscow Exchange is a relatively new market containing many fluctuating periods. So, testing middle, or short term investment periods like in previous studies may lead to misleading results.

The tests were applied to the daily, weekly, and monthly returns of the MOEX index, which helps this study to identify a limited number of factors causing the Moscow Exchange inefficiency.

The current study classified these factors to be rooted in price limits, the number of settlement days, and irrational behavior of investors, in contrast to the previous studies which left open broad interpretational possibilities when presenting their findings.

Also, the current study provides a discussion of previous efficiency researches in the Moscow Exchange, Then proposes to employ a test methodology that includes a non-linear independence test (BDS). For the first time, a study in the Russian stock market reveals an extent of non-linear correlation within the daily, weekly, and monthly returns, suggesting the presence of irrational behavior among a large number of investors at the Moscow Exchange.

In the end, this paper presents recommendations to investors in the Moscow Exchange that may help them find investment opportunities in the market and develop appropriate strategies to achieve abnormal returns.

2. Literature Review

The studies of Fama (1965b, 1970, 1991) are among the most important studies for researchers in the field of market efficiency analysis, because his methodology is still used to determine the price efficiency. Fama (1965b) tested the stock return performance in the Dow Jones index between 1956-1961 and concluded that a small percentage of changes in the price of a stock occur in conjunction with the previous change due to a stagnation in the trading of some stocks, thus the stock prices change randomly.

This was followed by the segmentation of efficiency levels in his study in 1970 (Fama, 1970). Also, Fama (1991) stated that the strong-form of efficiency is an optimal situation, but is not attainable. So important were the mentioned groundbreaking contributions of E. Fama to the field that all the other studies reviewed in this Paper reference at least one of his studies.

Evidence for the weak-form efficiency has been acknowledged in the context of European financial markets through the study of Conrad and Jüttner (1973) for the Germany, studies of Poon (1996), Evans (2006) for the U.K., De Pena and Gil Alana (2002) for the Spain, and Worthington and Higgs (2004) for the markets of Ireland, Portugal, and Sweden.

At the same time, the French financial market did not meet all the requirements of a random walk Borges, (2008). The study of Gilmore and McManus (2001) rejected the weak-form efficiency hypothesis for the weekly index returns at the Czech, Hungarian and Polish financial markets. Likewise, the study of Dorina and Simina (2007) rejected the weak-form efficiency hypothesis for the Lithuanian, Polish, Slovakian, Slovenian, Turkish and Romanian financial stock markets.

Kono, Yatrakis, and Segal (2011) and Rizvi and Arshad (2017) rejected the strong-form efficiency hypothesis for the Tokyo stock exchange, but proved it is semi strong efficient. The study of Hill and Motegi (2018) proved the weak-form hypothesis in the financial markets of Japan and China and rejected it for the U.S and U.K markets during the times of crises, such as the Iraqi war and the subprime crisis.

Also, the study of Bris et al. (2007) aimed to test the impact of short sales on financial market efficiency for time series data from 46 countries around the world.

Bris et al. found that the information gets reflected in prices faster in the markets where the use of short sales is allowed, whereas the market return is less skewed towards the negative returns in the markets of the countries where the use of short-selling is not allowed.

At the same time, the weak-form efficiency hypothesis has been rejected for the stock markets of some up-and-coming Asian countries: such as India (Kumar & Kumar, 2015; Thomas & Dileep Kumar, 2013), South Korea (Ayadi & Pyun, 1994), Pakistan, Sri Lanka, China, Korea, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Taiwan (Hamid, Suleman, Shah, & Akash, 2010).

In regard of the Arab stock markets, studies have also generally rejected the weak-form efficiency hypothesis respecting: the Damascus securities exchange (Abbas, 2014; Suleiman & Hazem, 2013), the stock exchanges in Saudi Arabia (Onour, 2009), the stock exchanges in Egypt (Hanaa, 2001), the stock exchanges in Kuwait (Al Saady, 2019), and the stock exchanges Oman, Iraq, Lebanon, Dubai, Saudi Arabia and Qatar (Asaad, Marane, & Omer, 2014; Zechariah, 1990). Some of these studies used advanced parametric and non-parametric methods to test the efficiency, including non-linear tests of efficiency such as the BDS, while other studies (e.g. Abbas (2014)) focused on institutional factors causing the stock exchange inefficiencies. Thus, it is possible to generalize that multiple studies have detected inefficiencies in the stock markets of developing countries and generally conclude about their inefficiency even at the weak form.

Focusing more immediately on the subject of the study, The Moscow Exchange is thought to exhibit the weak-form efficiency for a sample of monthly returns, but fails in achieving it for the daily and weekly returns because of the existence of serial autocorrelation between observations at these intervals.

The study of Abrosimova, Dissanaike, and Linowski, (2005) tested daily, weekly, and monthly index returns of Moscow Exchange for five years, using Autocorrelation tests, Variance ratio tests, ARCH models. The results show that the daily and weekly returns of the Moscow market are inefficient, while the monthly returns are efficient in the weak form; the researchers commented that the efficiency of the monthly return might be due to the small number of observed monthly observations.

The rest of the studies on the Moscow Exchange focused on studying the daily returns. The study of Al Saady (2020) tested the efficiency of MOEX daily returns for five years, using Correlation analysis and Long run variance tests. The study found that the Moscow Exchange is inefficient in the weak form.

Said, and Harper (2015) applied Variance ratio test, and Autocorrelation test to test the efficiency of MOEX daily returns for 9 years. The study found that the Moscow Exchange is not efficient in the weak-form inefficient from the weak form.

The results of Alexakis, Ignatova, & Polyanin (2019) contradict the findings of the previous authors; by using Martingale models and the Grainger causality test it is found that the prices at the Moscow Exchange exhibit the weak-form efficiency for daily observations.

Alexakis et al. (2019) used daily data of the sectoral indices at the Moscow Exchange. Thus, the results of that study may have been affected by the economic recessions and dips at the Moscow Exchange, as the Blue-Chip index of the Moscow exchange (MOEXBC) comprises just 15 companies, So, the current study argues that the findings of Alexakis et al. (2019) are not reliable.

Similarly, Darushin and Lvova (2014) analyzed the market efficiency of the Moscow Exchange at daily observations from the weak-form standpoint over the period of stability and the period of the financial crisis erupting in 2007-2009. The study used a sample of 20 stocks listed on the market. Using non-parametric tests, namely, the Kolmogorov-Smirnov test, Lilliefors test, and the Shapiro-Wilk test, the study found that the Moscow Exchange was weak form efficient during both the period of financial stability and the period of financial crisis.

Darushin and Lvova consider only a short-time horizon that covers just 4 years, on the other hand, the studied data are the stocks of companies that suffer from thin trading. So, their results may have been disproportionality affected by illiquidity, casting doubt on their accuracy from a statistical point of view. Similarly, the study of Nekrasova (2010) found that the returns at the Moscow Exchange exhibit the weak-form efficiency for daily observations by using the Darbin-Watson and Runs tests.

Table 1 presents a summary of the studies done for the Moscow Exchange, showing the name of the researcher, the year of the study, the frequency of observations used, the tests applied, and the general direction of the findings.

Table1. Summary of the studies on the Moscow Exchange

Author(s)	Year	Observations	Tests	Important results
Al Saady	2020	Daily returns	Correlation analysis, Long run variance.	Moscow Exchange not weak form efficient;
				There are a lot of speculators in the market.
Svanidze and Götz	2019	Daily returns	Analyze the market policies, information services and commodity futures markets	Moscow Exchange not weak form efficient
Alexakis et al.	2019	Daily returns	Autocorrelation test, Causality test.	Moscow Exchange is efficient in the weak form.
Omran	2017	Daily returns	Unit root test (ADF).	Moscow Exchange not weak form efficient
Said and Harper	2015	Daily returns	Variance ratio test, Autocorrelation test.	Moscow Exchange not weak form efficient.
Darushin and Lvova	2014	Daily returns	Kolmogorov Smirnov test, Lilliefors test, and Shapiro-Wilk test	Moscow Exchange is weak-form efficient
Nekrasova	2010	Daily returns	Darbin-Watson and the Runs test	Moscow Exchange is weak-form efficient.
Abrosimova et al.	2005	Daily, weekly, and monthly returns	Autocorrelation test, Variance ratio tests, ARCH models.	The daily and weekly returns at the Moscow Exchange are not weak form efficient.
				The monthly returns at the Moscow Exchange are weak form efficient.

Source: Prepared by authors.

Most of the researchers of the Moscow Exchange examine only the daily returns (Al Saady, 2020, Omran, 2017, A. Said & Harper,2015, Svanidze & Götz, 2019, Alexakis, Ignatova, & Polyanin, 2019, Darushin and Lvova, 2014, Nekrasova, 2010), considering that the instability of time series is one of the basic pre-conditions to prove the random walk hypothesis, but they do not notice that it is not sufficient to prove random walk hypothesis, because there may also be an auto-correlation between the returns series during the time. In addition, all the previous studies use short or disparate periods. Thus, the cited studies do not aggregate to a general conclusion of whether the Moscow Exchange is efficient in the weak form or not—leaving the question still open.

Only the study of Abrosimova et al. (2005) was concerned with the effect of data frequencies and tested the daily, weekly, and monthly returns - as the use of weekly and monthly data will reduce the impact of non-fundamental volatilities in the stock market. However, the study of Abrosimova et al. (2005) applied tests to data series of a relatively short time span than is characteristic for an efficiency study, which could have affected the outcome as discussed previously in the literature review.

With the exception of Omran (2017) study, which also uses the ADF test in its three modifications (and does only that), the current study is the only study prepared for the Moscow Exchange to date that uses the unit root tests, ADF, in all their three modifications (with Trend and Intercept, with Intercept, and without trend and intercept). But the author neglected that the unit root test is not sufficient to prove /disprove the random walk hypothesis.

Studies of Alexakis, Ignatova, & Polyanin,)2019(, and Nekrasova,)2014) used small samples of stocks, while efficiency studies are usually conducted on a general market index because it is representative of all stocks in the market. Furthermore, the data of a general market index do not suffer from lack of trading. So, the current study argues that these two studies may have misleading results.

Also, the current study applies Runs test in addition to the previous tests to examine the existence of linear correlation that was not indicated by the autocorrelation test (Q-Statistic), it should be noted that the Runs test was used in Fama (1965a).

The studies of Al Saady (2020), Omran (2017), Said and Harper (2015) point to irrational investors (speculators) investing in the Moscow Exchange, but they did not employ a non-linear test to examine the matter as the irrational (speculator) behavior has a nonlinear effect on stock market returns, as mentioned in the latest studies of Kocaarslan and Soytas (2019), Anufriev, Radi, and Tramontana (2018), Schmitt and Westerhoff (2014).

The current study uses the non-linear BDS test, since ignoring the presence of nonlinearities could lead to misleading results.

With regard to the above, the current study applies a test methodology consisting of parametric tests (namely, the ADF Unit Root Test and the autocorrelation test) and non-parametric tests (namely, PP Unit Root test, the Runs test, as well as the non-linearity BDS test as a new test methodology to test the weak-form efficiency for the Moscow Exchange).

3. Data and methods

The data used in this study consist of daily, weekly, and monthly MOEX index returns for the Russian stock market MOEX (Moscow Exchange, 2020). The Moscow Exchange which calculates the MOEX index hosts trading in equities, bonds, derivatives, currencies, money market instruments and commodities. The Moscow Exchange ranks among the world's top 20 exchanges by the total capitalization of shares traded, and also among the 10 largest exchange platforms for bonds and derivatives trading (Moscow Exchange, 2020b, 2020c). Its indices include: the MOEX Russia basic index and the RTS index, which aggregate the most liquid shares of the largest Russian issuers (Moscow Exchange, 2020); the Blue Chip index (Moscow Exchange, 2020a) which is based on 15 largest Russian companies by stock capitalization; Moscow Exchange SMID indices that comprise liquid shares of small and medium capitalization, listed in Russia (Moscow Exchange, 2020b); and the Broad Market Index which includes the top 100 stocks selected by their liquidity, capitalization and free float (Moscow Exchange, 2020b). The components of the broad market index are also subdivided into industry indices.

The Moscow Exchange indices are calculated in rubles and in the US dollars. However, this study relied on index returns quoted in rubles, the trading currency, thus excluding the currency fluctuation effects.

Table 2 summarizes the number of sectors and the number of companies listed on the stock exchange that the surveyed index includes, as well as the number of settlement days on the Russian stock exchange in the period 2005-2019.

Table 2. Summary of the Moscow Exchange

Index	Number of sectors	Listed companies	No. settlement days	Overall description
MOEX	8	50	3	MOEX Russia Index is capitalization-weighted composite index calculated based on prices of the most liquid stocks of Russian issuers from various sectors. MOEX Russia Index (previously called MICEX Index) was launched on September 22, 1997 at base value of 100.

Source: Prepared by authors (Moscow Exchange, 2020b)

Figure 1 shows a breakdown of the trading turnover for the Moscow Exchange by the major client group. Podgorny (2017) concludes that professionals investors (dealers, institutional investors, and assets managers) are mostly speculators. Also, Lomakin, Korneev, Kurgan, and Machinskaya (2018) indicates that a large proportion of non-resident investors on the Moscow Exchange are a specie of speculators looking for arbitrage opportunities in international markets. Mirkin, Khestanov, Andryushenko, and Volkova (2015) also carries a mention that there is a large number of speculators on the Moscow Exchange. Thus, a fair estimate is that more than 50% of investors at the Moscow Exchange can be regarded as speculators .

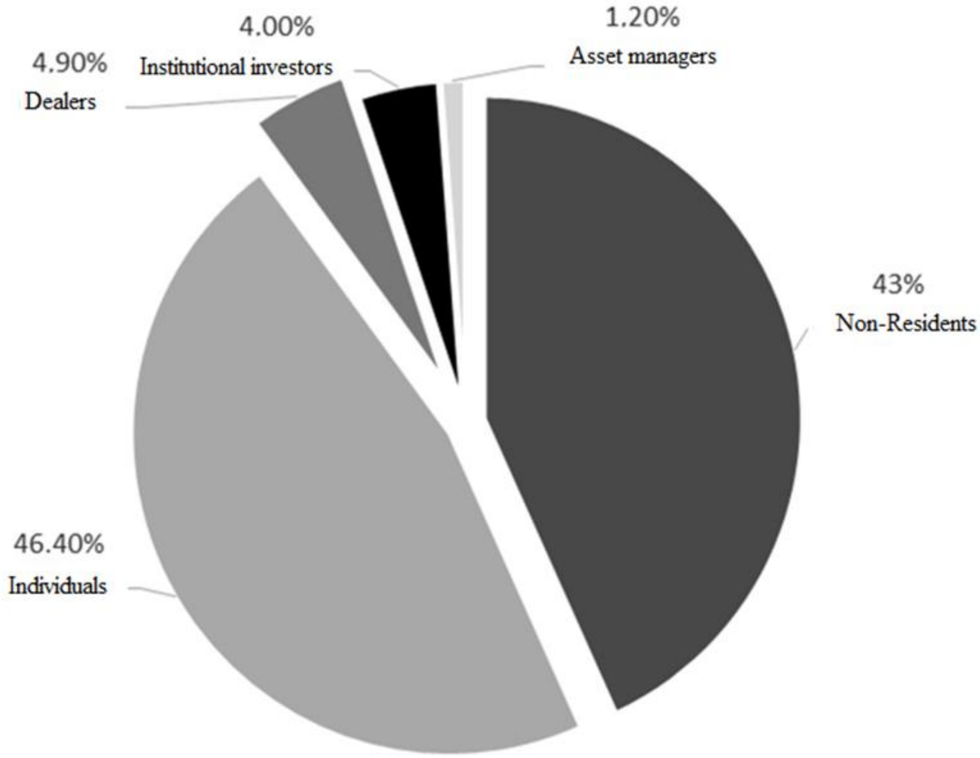

Figure 1. Breakdown of the Moscow exchange turnover by the client group

Source: the Moscow Exchange fact sheets of equity indices (average of the set of reports over the 2017-2019 period (Moscow Exchange, 2020c))

The study sample includes 3537 daily observations, 702 weekly observations and 178 monthly observations of the index covering the period from the 3-rd of Jan. 2005 to 10th of Jan. 2019. The data was collected from the official website of the Moscow Exchange (RTSI Archive). The natural log of the ratio of the closing prices was used for the daily, weekly and monthly index frequencies to produce a time series of continuously compounded returns, such as that:

Log R_t=Log (P_t/P_(t-1))   (1)

where   Log R_t – the natural log of closing prices; Pt, and Pt-1 represent the value of the index at time t and t-1, t∈ {1,2,…,X}. . Where X represents a natural number for any day, week, or month during the study period .

This study used Excel 2010, SPSS 17.0 and EViews 7 software packages to perform the following tests:

Unit Root Test

Unit root tests are used to examine the random walk hypothesis of returns with and without trend and intercept (Hamilton, 1994).

The unit root test is necessary but not a sufficient condition for the random walk hypothesis to hold. The unit root has predictable properties, but the random walk of returns means that prices do not have to be correlated. So, this test is usually applied along with the autocorrelation test, Runs test or ARCH test prediction models (Abrosimova et al., 2005; Al Saady, 2020).

The original Dickey and Fuller paper (Dickey & Fuller, 1979) was concerned with the study of the US stock market returns and did not reject the null hypothesis of the test which stated that the returns are following a random walk. Thus, their study didn’t disprove that the annual returns of the American stock market follow a random walk.

Later, an autocorrelation problem had been found in the Dickey and Fuller test (Nelson & Plosser, 1982). So, the study of Said and Dickey (1984) augmented the model of Dickey and Fuller test and, again, the results of the Augmented Dickey and Fuller test (ADF) weighed in favour of the random walk hypothesis.

Later, Phillips and Perron (1988) created a new non-parametric model in order to solve the problem of autocorrelation in Dicky and Fuller model. The results of Phillips and Perron test confirmed the random walk hypothesis, too.

Augmented Dicky and Fuller Test (ADF)

This test uses the ordinary least-squares method (OLS) of the time series with reference to the first lag of the series (Gilmore & McManus, 2001).

The null hypothesis for ADF could be written in several ways with the meaning as follows:

The time series follow a random walk with trend (Abrosimova et al., 2005).

The time series non stationary (Gilmore & McManus, 2001).

The time series has a unit root; thus, it follows a random walk (Alahmad, 2012).

The null hypothesis for ADF is tested against two alternative hypotheses:

The time series follow a stationary trend.

The time series follow a stationary trend and intercept.

The general formula of ADF model is:

$$\Delta R_t=\beta_1+\beta_2 T+\delta R_{(t-1)}+\sum_{(k=1)}^{(k=i)} \rho_k \Delta R_{(t-k)}+\varepsilon_t \qquad (2)$$

where ΔR_t is the difference generator, which is a difference in the values between succeeding and preceding terms in the time series; β_1 intercept; β_2 – time trend coefficient; k the number of lags; ε_t error coefficient, which is known as white noise and belongs to the space {0, δ2} (Alahmad, 2012; Groebner, Shannon, Fry, & Smith, 2007).

Phillips and Perron Test (PP)

This test uses OLS similar to Dicky and Fuller test, but for solving the autocorrelation problem the PP test contains a non-parametric correction for the mean of the equation. This test uses similar null- and alternative-hypotheses to the ADF test.

The general formula of the PP test is:

$$\Delta R_t=\beta_1+\beta_2 T+\rho R_{(t-1)}+\varepsilon_t \qquad (3)$$

where ΔR_t is the difference generator; β_1 – intercept; β_2 – time trend coefficient; T is the deterministic trend term; ρ – is the slope of the regression relationship between the original series values and its first difference values; and ε_t – is the error term. The difference between the PP and ADF equations is that PP is a subject to a nonparametric correction of its ρ value.

It should be noted, that the PP test results are less accurate than the results of ADF tests when small samples are examined, though both tests are capable of examining small samples that may contain less than 30 observations. The PP test is distinct from the ADF test in that it does not need to have the distinct studied lag times determined, thus providing more comprehensive results (Kwiatkowski, Phillips, and Schmidt, & Shin, 1992).

Autocorrelation Test

This test measures the significance of the relationship between the current return and the previous returns in the same series. A random returns chain has zero autocorrelation value (Hamid et al., 2010).

Instead of using an autocorrelation test for each lag alone, the Ljung-Box technique was developed as a method for conducting the Q-stat test and discussing the following null hypothesis:

The autocorrelation coefficients for all the studied lags are not significantly different from zero.

Against the alternative hypothesis:

There are autocorrelation coefficients for the studied lag values that significantly differ from zero.

Ljung-Box equation is applied to calculate the value of Q-stat according to the following formula (Abbas, 2014):

$$Q_{LB}=N(N+2) \sum_{(k=1)}^{K} \frac{p_k(\varepsilon t)^2}{N-k} \qquad (4)$$

where $p_k(\varepsilon t)^2$ is the autocorrelation value for the studied lag period K; K □ the maximum number of the lag periods examined; and N □ represents the number of observations.

It should be noted that the autocorrelation test does not require the assumption of normal distribution for the sample observations, and is applied within a Chi-square distribution space with K degrees of freedom (Alahmad, 2012).

Parametric tests for dependence, such as the tests for correlation, are sensitive to deviations away from normality or other assumed distributions. Since financial series are generally characterized by non-normality and nonlinearity, it is important to perform tests for dependence that hold for any returns distribution. Two non-parametric tests, which impose no prior requirements concerning the distribution of returns, are used in this study: the Runs test relies only on the signs (or deviations from the central tendency) of successive returns, regardless of their dimensionality, and there are no prior assumptions about a distribution of the returns. Last but not least, the non-parametric BDS test is also used in this study to detect nonlinear correlations in the returns series. This test is useful for identifying serial dependence in time series.

Runs test

This test analyzes uninterrupted sequences of security price changes; the price stability is indicated by the symbol (0). Any change that increases a security price is indicated by the symbol (+), and a change that reduces its price is indicated by the symbol (-); inversion of the symbol in a succession of security returns implies the beginning of a new pattern (Run). So, to test for the price independence assumption in a price series, the number of sign patterns that occur randomly in the series is counted, whereupon the Runs test is usually used to find the existence of statistical correlation relationships that are not detected by the autocorrelation test (Abbas, 2014; Moustafa, 2004).

The current study codes the values above the median return as positive and values below the median as negative. A Run is defined as a series of consecutive positive (or negative) values.

The null hypothesis is defined as:

The sequence was produced in a random manner.

Against the alternative hypothesis:

The sequence was not produced in a random manner.

According to Imbens & Wooldridge (2009) the test statistic Z required for the actual number of runs in the Runs test is calculated according to the following formula:

$$Z=\frac{R-E(R)}{\sigma_R} \quad (6)$$

where R is the observed number of runs; E(R) is the expected number of Runs; and σ_R is the standard deviation of the number of runs.

The values of E(R) and σ_R are computed as follows:

$$E(R)=\frac{2n_a . n_b}{n_a+n_b}+1 \quad (7)$$

$$\sigma_R=\sqrt{\frac{2n_a n_b (2n_a n_b-n_a-n_b)}{(n_a+n_b)^2 (n_a+n_b-1)}} \quad (8)$$

where n_a and n_b are the number of positive and negative Runs in the series, respectively.

The Runs test rejects the null hypothesis if:

$$|Z|> Z_{(1-\alpha/2)} \quad (9)$$

where threshold $Z_{(1-\alpha/2)}$ value is found in the standardized normal distribution table for significance level α=5% used in the current study.

The Brock, Dechert and Scheinkman (BDS) test

This test was designed by Broock, Scheinkman, Dechert, and LeBaron (1996) to test the possibility that a series of returns is randomly changing over time with a property of homogeneous independence and distribution.

The study of Oprean (2012) finds out that there is a non-linear correlation in the stock returns for developing countries due to the irrational behavior of most participating parties in these markets.

Also, the study of Abbas (2014) determines the presence of non-linear correlation between the daily return series of Damascus securities exchange.

While the study of Dorina and Simina (2007) have reported the presence of linear and nonlinear dependencies between the daily return series in the following financial markets: Slovenia, Lithuania, Slovakia, Turkey, Romania, and Poland.

The BDS test null-hypothesis is:

Time series values move independently and are homogeneous over time.

Against the alternative hypothesis:

Time series values do not move independently over time and include a set of nonlinear correlations with time.

The formula for the BDS test is:

$$W(T,m,e)=\frac{\sqrt{T}\{[C(T,m,\varepsilon)-C(T,1,\varepsilon)]^m\}}{\sigma(T,m,\varepsilon)} \quad (10)$$

where { $W(T,m,e)$ } is an auto integral function; $T = N-m + 1$, with T - the length of the series; m □ the number of lags; C- the Grassberger and Procaccia correlation integral.; Ɛ □ an error correction factor which is a very small value; { σ (T, m, Ɛ)} □ maximum prediction error which is an estimate of the asymptotic standard error of $[\{C(T,m,\varepsilon)-C(T,1,\varepsilon)]^m\}$.

The BDS test usually needs a large sample to ensure proper performance. It is usually thought that 500 observations are the minimal sample size for the BDS test to have reliable performance, and ε takes values between one half and two times the standard deviation.

4. Results

Statistical Properties of the Surveyed Index Return Time-Series

Table 3 presents the summary of descriptive statistics for daily, weekly and monthly returns for the Moscow Exchange index MOEX.

Table 3. Summary of descriptive statistics for the daily, weekly and monthly returns surveyed

Observations	Mean	Std.Dev.	Skewness	Kurtosis	Jarque-Bera	Prob.
Daily	0.000116	0.020962	(0.429152)	14.90374	20991.46	0.000
Weekly	0.000503	0.046252	(0.577105)	6.438484	384.7948	0.000
Monthly	0.003537	0.094431	(0.857711)	6.347769	99.05162	0.000

* The value inside brackets is negative

Source: Prepared by authors.

A comparison of the mean values for daily, weekly and monthly returns with their Standard Deviation values through the coefficient of variation (C.V.) shows that the Moscow Exchange offers 0.055% of marginal daily income, 1.08% of weekly income and 3.75% of monthly income for every additional unit of risk. The negative skewness values for the daily, weekly and monthly returns -0.43, -0.58, -0.86, respectively, indicate that the probability of losing money at random investing is greater than the probability of achieving profit at the Moscow Exchange. The difference of the skewness value from zero indicates that the distribution of observations does not follow a normal distribution. The large positive values of kurtosis for daily, weekly and monthly returns 14.90, 6.43, 6.35, respectively, indicate that the distribution curve has a pointed shape. So, most of the returns are centered around the mean. The peak value of kurtosis is greater than 3 which is the kurtosis value of the normal distribution. Thus, returns distributions do not follow a normal distribution pattern according to this test, too. Jarque-Bera statistic and the corresponding p-values are also used to test the null hypothesis implying that daily, weekly and monthly distributions of the market returns are normal: the resulting p-values are zero at the 5% level of significance suggesting that the null hypothesis of the normality of returns is rejected.

From the above, the results of the Skewness, Kurtosis, and Jarque-Bera statistics provide evidence that the distributions of daily, weekly and monthly returns for the Moscow Exchange do not follow the normal distribution.

Unit Root Tests

Table 4 shows that the calculated values for daily, weekly and monthly returns of the index for the ADF and PP tests are smaller than the threshold statistical values at the 5% significance level for all the consecutively-applied versions of the unit root tests (with trend and intercept, with intercept, without trend and intercept).

This means that the returns series are stable. Thus, there exists an ARCH formula without trend and Intercept that can predict changes in the index returns. Fundamental analyses or technical analysis techniques, such as the waves theory and the Japanese candlestick chart, can be used to predict changes in the values of such stock market index with a higher-than-random degree of accuracy. The existence of a time regression relationship in the formula without trend and intercept suggests that the values of the index move around a constant average. Thus, the Moscow Exchange index is not efficient in the weak-form according to the ADF and PP unit root test results with reference to data of daily, weekly and monthly frequencies.

Table 4. Results of ADF and PP tests for the index returns of daily, weekly and monthly frequencies

ADF test			PP test			Equation type
t-test	**5%**	**Prob.**	**Adj. t-test**	**5%**	**Prob.**	
			Daily Returns			
(53.75)	(3.41)	0.000	(53.61)	(3.41)	0.000	With Trend and Intercept
(53.76)	(2.86)	0.000	(53.61)	(2.86)	0.000	With Intercept
(53.76)	(1.94)	0.000	(53.62)	(1.94)	0.000	Without trend and intercept
			Weekly Returns			
(25.29)	(3.42)	0.000	(25.63)	(3.42)	0.000	With Trend and Intercept
(25.30)	(2.87)	0.000	(25.64)	(2.87)	0.000	With Intercept
(25.32)	(1.94)	0.000	(25.66)	(1.94)	0.000	Without trend and intercept
			Monthly Returns			
(10.10)	(3.44)	0.000	(10.22)	(3.44)	0.000	With Trend and Intercept
(10.10)	(2.88)	0.000	(10.21)	(2.88)	0.000	With Intercept
(10.12)	(1.94)	0.000	(10.24)	(1.94)	0.000	Without trend and intercept

Source: Prepared by authors.

The Autocorrelation Test Results

Table 5 summarizes the results of the Q-statistics and their probability value (Prob.) according to Ljung-Box method at 5% significance level. Also, table 5 shows the residuals of total autocorrelation (AC) and partial autocorrelation (PAC) affecting daily, weekly and monthly returns of the indices. The results of the test applied to daily trading frequencies show the returns at the Moscow Exchange affected by autocorrelation for 15 days since p-value < 5% for each lag.

The same finding is exhibited for monthly trading frequencies, showing the returns at the Moscow Exchange are affected by autocorrelation over the test period since p-value < 5%. Furthermore, the values of both AC and

PAC show a rapid decline after the first lag, indicating that there is possibility of predicting future changes in the MOEX returns.

Thus, both null-hypotheses of no autocorrelation for daily and monthly returns were rejected.

PAC and AC values are positive for lag K=1 at daily and monthly frequencies, and also at K=2 for the monthly frequency, pointing to the existence of a positive correlation between the returns of the index at daily and monthly frequencies.

On the other hand, the null hypothesis of no autocorrelation in the index at the weekly return frequency was accepted for K∈{1,2,3,4,5,10,11,12,13,14,15} since the p-value>5%, but rejected for K∈{6,7,8,9} since p-value < 5%; accordingly, the weekly returns can be modestly affected by an autocorrelation too.

The findings of the autocorrelation test for daily observations are consistent with previous studies for the Moscow Exchange such as Alexakis et al. (2019), Omran (2017), Said and Harper (2015), Abrosimova et al. (2005).

Whereas the results of Abrosimova et al. (2005) indicate acceptance of the null hypothesis of no autocorrelation at monthly return frequencies, the current study rejects this, mostly because of using a longer period in the current study.

Table 5. Results of the autocorrelation test for daily, weekly, and monthly returns according to Ljung-Box method

K	**AC**	**PAC**	**Q-Stat**	**Probability**
Results of the autocorrelation test for daily returns according to Ljung-Box method				
1	0.100	0.100	35.676	0.000
2	-0.007	-0.017	35.853	0.000
3	-0.032	-0.029	39.378	0.000
4	0.000	0.006	39.378	0.000
5	-0.007	-0.009	39.566	0.000
6	0.011	0.012	39.998	0.000
7	0.019	0.017	41.272	0.000
8	-0.060	-0.065	54.067	0.000
9	-0.007	0.007	54.231	0.000
10	-0.005	-0.005	54.325	0.000
11	0.024	0.021	56.317	0.000
12	0.016	0.013	57.260	0.000
13	0.037	0.034	62.243	0.000
14	0.013	0.008	62.840	0.000
15	-0.021	-0.019	64.357	0.000
Results of autocorrelation test for weekly returns according to Ljung-Box method				
1	0.044	0.044	1.3573	0.244
2	0.039	0.037	2.4323	0.296
3	-0.035	-0.039	3.3047	0.347
4	0.087	0.089	8.6803	0.070
5	0.042	0.037	9.9155	0.078
6	0.080	0.070	14.501	0.025
7	-0.014	-0.017	14.646	0.041
8	0.056	0.048	16.865	0.032
9	-0.021	-0.026	17.191	0.046
10	0.024	0.008	17.619	0.062

K	AC	PAC	Q-Stat	Probability
11	0.049	0.051	19.334	0.055
12	-0.002	-0.023	19.337	0.081
13	0.058	0.062	21.773	0.059
14	0.005	-0.005	21.789	0.083
15	-0.049	-0.059	23.516	0.074
Results of autocorrelation test for monthly returns according to Ljung-Box method				
1	0.266	0.266	12.831	0.000
2	0.139	0.074	16.359	0.000
3	0.121	0.072	19.028	0.000
4	-0.025	-0.088	19.145	0.001
5	-0.071	-0.067	20.076	0.001
6	-0.080	-0.049	21.259	0.002
7	-0.135	-0.088	24.655	0.001
8	-0.018	0.063	24.716	0.002
9	-0.029	-0.015	24.878	0.003
10	-0.002	0.019	24.879	0.006
11	0.011	-0.013	24.903	0.009
12	0.010	-0.004	24.923	0.015
13	-0.112	-0.141	27.360	0.011
14	-0.074	-0.032	28.429	0.012
15	-0.034	0.020	28.652	0.018

Source: Prepared by authors.

Runs test

Table 6 summarizes the results of the Runs test performed. The number of actual daily, weekly and monthly runs in the Moscow Exchange index for the period under survey is 2306, 419, 124, respectively – that is, more than the threshold number of runs (885, 174, 49 - for each respective frequency) to accept the random walk hypothesis at the 5% significance level, therefore the Runs test results reject the random-walk hypothesis for daily, weekly and monthly returns of the Moscow Exchange index.

The positive value of Z for daily, weekly and monthly returns was 18.089, 5.589, 4.091, respectively, which is higher than the 1.96 threshold - pointing to the existence of a negative correlation between the returns of the index at daily, weekly and monthly frequencies.

The Runs test supports the results of the autocorrelation test and ADF and PP unit root tests for daily, weekly, and monthly observations and provides an additional reason for rejecting the weak-form efficiency hypothesis for the Moscow Exchange.

The Runs test contradicted the Autocorrelation test for daily and monthly observations, with the Runs test pointing to the existence of a negative correlation between the returns of the index at daily and monthly frequencies, while the Autocorrelation test points to the existence of a positive correlation between them; but due to the result of ADF and PP unit root tests in this market, there is a possibility that a nonlinear correlation effect may not be revealed by an autocorrelation test if it is a parametric test. Therefore, the current study has found a mixed result about the daily and monthly returns efficiency at weak form for the Russian stock market. Thus, the BDS test was further applied to test the possibility of a nonlinear correlation within the daily, weekly and monthly index returns.

Table 6. Results of Runs test for daily, weekly and monthly index returns

Index	Test value (Median)	Cases< test value	Cases> test value	Total cases	Actual No. of Runs	Expected No. of runs	Z	Asymp. Sig (2Tailed)
Daily	1	1726	1811	3537	2306	885	18.089	0.000
Weekly	1	396	306	702	419	174	5.589	0.000
Monthly	1	92	98	190	124	49	4.091	0.000

Source: Prepared by authors.

The Brock, Dechert and Scheinkman (BDS) test

Table 7 summarizes the values of the BDS non-linear independence test as the first number entry and its associated probability value (Prob. at the 5% significance level) as the second number entry in each cell. Table 7 results show that the calculated test values are significant at the 5% significance level. Therefore, the BDS test null-hypothesis, which states that the returns of the studied series are independent and symmetrically distributed, is rejected.

This result gives further evidence to reject the random walk hypothesis in regards of returns at the Moscow Exchange, as evidenced by the existence of an effect of non-linear correlation between the index returns. Thus, according to this test, the Moscow Exchange market is inefficient at the weak-form for daily, weekly and monthly trading frequencies.

Irrational behavior is one of the reasons for Moscow Exchange inefficiencies for daily, weekly and monthly returns, as there is an effect of linear and nonlinear factors in these markets.

Non-linear correlation between index returns has been documented for the developing country markets. Oprean (2012) has explained the presence of nonlinear correlation as originating due to non-linear stock price changes in these markets on account of irrational behavior of large numbers of investors in them.

After comparing these results with Figure 1 discussion and Al Saady (2020) findings, we assume that a nonlinear correlation might be due to a speculative behavior from a large number of investors on the Moscow Exchange. However, this finding still requires further validation.

Table 7. Results of the BDS Test for daily, weekly and monthly returns of the index

Index \ Embedding Dimensions (m)	m2	m3	m4	m5
Daily	0.018 0.000	0.027 0.000	0.027 0.000	0.023 0.000
Weekly	0.017 0.000	0.023 0.000	0.025 0.000	0.022 0.000
Monthly	0.022 0.0003	0.030 0.000	0.028 0.000	0.026 0.000

Source: Prepared by authors.

5. Discussion

Table 8 summarizes the results of parametric and non-parametric tests applied in the context of the current study. According to the results obtained under the unit root tests (the ADF and PP), the daily, weekly and monthly return variations are seen to be stationary. Therefore, these tests reject the weak-form efficiency hypothesis for the Moscow Exchange.

The current study findings are consistent with Abrosimova et al. (2005) results and indicate the Moscow Exchange market to be inefficient with respect to daily and weekly index observations. Whereas the results of Abrosimova et al. (2005) study pronounced the Moscow Exchange index to be weak-form efficient for monthly observations, the current study balanced view is that it is likewise inefficient at this trading frequency, mostly because of using a longer period in the current study.

The departures from its efficiency may be induced by price limits, and the number of settlement days, as well as irrationally-acting market participants. A series of preceding studies for the Moscow Exchange have reached similar conclusions with respect to daily observations (Alexakis et al., 2019; Omran, 2017; Said & Harper, 2015).

In order to have more conclusive and multi-dimensional results, this study also brought the autocorrelation test and the Runs test to bear on the issue.

The autocorrelation test and the Runs test results regarding the weekly and monthly return auto-correlation indicate a possibility for a non-linear correlation effect between the studied return series data, same as found in Abbas (2014) study for the Damascus Securities Exchange, and Dorina and Simina (2007) study for Hungarian, Czech, Lithuanian, Polish, Slovakian, Slovenian and Turkish stock markets.

After applying the Non-Linear Independence Test (BDS), this study found a non-linear correlation within daily, weekly and monthly index return frequencies. This result suggests that a large number of irrational investors are investing on the Moscow Exchange. Furthermore, BDS and Runs test results show that the investors are underestimating returns on the Moscow Exchange when new information reaches the market, but, after comparing those results with the results of Al Saady (2020), the current study suggests that the reason for non-linear correlation between the returns on the Moscow Exchange can be attributed to the presence of a large number of speculators on the market, not just irrational investors who are underestimating returns.

Similar results had been reported for the financial markets of developed countries (Lakonishok & Vermaelen, 1990; Lucas, 1978).

Table 8. Results of the applied tests*

Index \ Test	BDS	Runs test	Autocorrelation	PP	ADF
Daily	+	+	+	+	+
Weekly	+	+	+/-	+	+
Monthly	+	+	+	+	+

Source: Prepared by the researcher.

6. Suggested investment trading strategies

The current study rejects the weak-form efficiency hypothesis for the Moscow Exchange. Thus, depending on the results obtained under ADF and PP tests, the investors could build ARCH estimation models to find the best model which can get the highest abnormal return in the Moscow Exchange, like in the study of Abrosimova et al. (2005), but, the time horizon of the current study 14 years. Thus, the estimation model will not be accurate for the following reasons:

Estimation models assume normally distributed returns. Normality is a better approximation for short horizons like a month than for longer horizons, where skewness becomes increasingly important (Fama, 1976, 1996).

The estimation models can give false impressions of the speed of price adjustment to an event. The reason is that the estimation of the models can grow with the returns horizon, when there is no abnormal return after the first period, Mitchell and Stafford (1997).

On the other hand, there are several directions which could be promising for future research on the field of violations of market efficiency. It would be interesting to see some evidence on widely used investment strategies on the international stock markets, namely contrarian strategy and momentum strategy .

Recently Semenkova (2020) found that irrational traders often exacerbate anomalies in the Moscow Exchange. As a result, the market price of an already overvalued share will rise, while undervaluation will fall, and arbitrage operations will never bring the share price to its fair value.

Taking into account Semenkova results and the ratio of speculative investors in Moscow Exchange , it can be assumed that inefficiency of the Moscow Exchange is due to the prevalence of irrational investors, the pricing process is difficult to characterize "as a fair pricing process".

Therefore, in the current situation on the Moscow Exchange, a different pricing paradigm namely noise trading seems more able to explain the price changes. Furthermore, Semenkova (2020) suggests that using the contrarian strategy could achieve abnormal returns on the Moscow Stock Exchange.

Moskowitz et al. (2012) mentioned to persistence in returns for one to 12 months (in the markets of: Australia, France, Germany, Italy, Japan, Netherlands, Spain, the United Kingdom, and the United States of America) that partially reverses over longer horizons, Thus, momentum strategies across all asset classes deliver abnormal returns with little exposure to standard asset pricing factors and perform best during extreme markets.

After Moskowitz et al. examining equity index, currency, commodity, and bond futures for each of the 58 liquid instruments, and the trading activities of speculators and hedgers, they find that speculators profit from time-series momentum at the expense of hedgers.

Also, Hart et al. (2003) examine the profitability of a broad range of stock selection strategies in 32 emerging markets, of which the Moscow Exchange is one of them. The study confirmed the profitability of trading strategies based on value and momentum in emerging markets, in contrast to strategies based on size, liquidity and mean reversion.

The results of the current study that the Moscow exchange is inefficient associated with the results of Semenkova (2020), and Hart et al. (2012) that contrarian, and momentum investors achieve abnormal returns when there is a violation of efficiency market theory.

From the above, the current study concluded that using contrarian strategy and momentum strategy may lead investors to profitable trading rules in the Moscow Exchange.

7. Conclusion

This study tested the weak-form efficiency for daily, weekly and monthly return trading frequencies of the MOEX index of the Moscow Exchange for the period from 03/01/2005 to 10/01/2019. Both the parametric test approaches (namely, the ADF Unit Root Test and the autocorrelation test) and non-parametric tests (namely, the PP Unit Root test, the Runs test and the BDS test of nonlinearity) were employed to test the weak-form efficiency hypothesis for the Moscow Exchange. Answering the study question, the results obtained under the ADF and PP unit root tests suggest that the daily, weekly and monthly return variations are stationary. Therefore, the weak-form efficiency hypothesis is rejected for the Moscow Exchange. With regard to the results of the autocorrelation test, the Runs test and the BDS test, the current study attributes the observed inefficiency of the Moscow Exchange daily, weekly and monthly returns to linear factors (which are the price limits, the number of settlement days) and a non-linear factor (speculative behavior of a large group of investors at the Moscow Exchange). Thus, the daily, weekly, and monthly returns of the Moscow Exchange index are inefficient at the weak-form. An essential reason for that is the prevalence of speculative behavior in a large group of investors at the Moscow Exchange. In consequence, the Moscow Exchange offers opportunities for achieving abnormal returns for investors, but it also carries high risks which make investors cautious of investing into it.

This study suggests that using contrarian strategy and momentum strategy may lead investors to profitable trading rules in the Moscow Exchange

References

Abbas, G. (2014). Testing Random Walk Behavior in the Damascus Securities Exchange. International Journal of Academic Research in Accounting, Finance and Management Sciences, 4(4), 317–325. https://doi.org/10.6007/IJARAFMS/v4-i4/1368

Abrosimova, N., Dissanaike, G., & Linowski, D. (2005). Testing Weak-Form Efficiency of the Russian Stock Market (SSRN Scholarly Paper No. ID 302287). https://doi.org/10.2139/ssrn.302287

Al Saady, W. (2019). Testirovaniye povedeniya sluchaynykh bluzhdaniy na finansovom rynke Kuveyta [Testing the behavior of random walks in the financial market of Kuwait]. Bulletin of the Russian Economic University. G.V. Plekhanov. Introduction. The Way To Science, 1(25), 43–53. Retrieved from https://elibrary.ru/item.asp?id=37259364

Al Saady, W. (2020). Vliyaniye obstrela iranom amerikanskikh baz na dokhodnost' neftyanykh indeksov I mirovykh fondovykh indeksov [The Impact of Iran's Shelling of American Bases on the Profitability of Oil Indices and World Stock Indices]. Financial Economics, 2, 238–243. Retrieved from https://elibrary.ru/item.asp?id=42469884

Alahmad, Z. (2012). Testing the Weak Form Efficiency of the Damascus Securities Exchange. International Research Journal of Finance and Economics, 85, 154–166.

Alexakis, C., Ignatova, T., & Polyanin, A. (2019). Tests for Sectorial Market Efficiency of the Dynamics in Moscow Exchange. Espacios, 40(10), 17. Retrieved from https://papers.ssrn.com/abstract=3408791

Altamimi, A. F. (2012). Financial markets are a framework for regulation and evaluation of instruments. Amman: Dar Al-Yazouri.

Anufriev, M., Radi, D., & Tramontana, F. (2018). Some reflections on past and future of nonlinear dynamics in economics and finance. Decisions in Economics and Finance, 41(2), 91–118. https://doi.org/10.1007/s10203-018-0229-9

Asaad, Z., Marane, B., & Omer, A. (2014). Testing the Efficiency of Iraq Stock Exchange for Period (2010-2014) An empirical Study. Journal of University of Duhok, 32(2), 57–80.

Ayadi, O. F., & Pyun, C. S. (1994). An application of variance ratio test to the Korean securities market. Journal of Banking & Finance, 18(4), 643–658. https://doi.org/10.1016/0378-4266(94)00012-3

Borges, M. R. (2008). Efficient market hypothesis in European stock markets (No. WP 20/2008/DE/CIEF; pp. 1–20). Retrieved from School of Economics and Management website: http://www.tandfonline.com/doi/abs/10.1080/1351847X.2010.495477

Bris, A., Goetzmann, W. N., & Zhu, N. (2007). Efficiency and the Bear: Short Sales and Markets Around the World. The Journal of Finance, 62(3), 1029–1079. https://doi.org/10.1111/j.1540-6261.2007.01230.x

Broock, W. A., Scheinkman, J. A., Dechert, W. D., & LeBaron, B. (1996). A test for independence based on the correlation dimension. Econometric Reviews, 15(3), 197–235. https://doi.org/10.1080/07474939608800353

Carhart, M. M. (1997). On Persistence in Mutual Fund Performance. The Journal of Finance, 52(1), 57–82. https://doi.org/10.1111/j.1540-6261.1997.tb03808.x

Conrad, K., & Jüttner, D. J. (1973). Recent behaviour of stock market prices in Germany and the random walk hypothesis. Kyklos, 26(3), 576–599. https://doi.org/10.1111/j.1467-6435.1973.tb01882.x

Darushin, I. A., & Lvova, N. A. (2014). Otsenka effektivnosti rossiyskogo finansovogo rynka neparametricheskim metodom [Evaluation of the effectiveness of the Russian financial market by the nonparametric method]. Finance and Credit, 48(624), 14–24. Retrieved from https://cyberleninka.ru/article/n/otsenka-effektivnosti-rossiyskogo-finansovogo-rynka-neparametricheskim-metodom

De Peña, J., & Gil-Alana, L. A. (2002). Do Spanish Stock Market Prices Follow a Random Walk? In Faculty Working Papers (No. 01/02). Retrieved from School of Economics and Business Administration, University of Navarra website: https://ideas.repec.org/p/una/unccee/wp0102.html

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74(366), 427–431. https://doi.org/10.2307/2286348

Dorina, L., & Simina, U. (2007). Testing efficiency of the stock market in emerging economies. The Journal of the Faculty of Economics-Economic Science Series, 2, 827–831.

Evans, T. (2006). Efficiency tests of the UK financial futures markets and the impact of electronic trading systems. Applied Financial Economics, 16(17), 1273–1283. https://doi.org/10.1080/09603100500438767

Fama, E. F. (1963). Mandelbrot and the Stable Paretian Hypothesis. The Journal of Business, 36(4), 420. https://doi.org/10.1086/294633

Fama, E. F. (1965a). Random Walks in Stock Market Prices. Financial Analysts Journal, 21(5), 55–59. https://doi.org/10.2469/faj.v21.n5.55

Fama, E. F. (1965b). The Behavior of Stock-Market Prices. The Journal of Business, 38(1), 34-105. https://doi.org/10.1086/294743

Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. The Journal of Finance, 25(2), 383–417. https://doi.org/10.2307/2325486

Fama, E. F. (1991). Efficient Capital Markets: II. The Journal of Finance, 46(5), 1575–1617. https://doi.org/10.1111/j.1540-6261.1991.tb04636.x

Fama, E. F., & French, K. R. (1992). The Cross-Section of Expected Stock Returns. The Journal of Finance, 47(2), 427–465. https://doi.org/10.1111/j.1540-6261.1992.tb04398.x

Fung, W., & Hsieh, D. A. (1997). Empirical Characteristics of Dynamic Trading Strategies: The Case of Hedge Funds. Review of Financial Studies, 10(2), 275–302. https://doi.org/10.1093/rfs/10.2.275

Gilmore, C. G., & McManus, G. M. (2001). Random-Walk and Efficiency Tests of Central European Equity Markets. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.269510

Groebner, D. F., Shannon, P. W., Fry, P. C., & Smith, K. D. (2007). Describing Data Using Numerical Measures. In Business Statistics: A Decision Making Approach (7th ed.). Upper Saddle River, N.J: Prentice Hall.

Hamid, K., Suleman, M., Shah, S., & Akash, R. (2010). Testing the Weak Form of Efficient Market Hypothesis: Empirical Evidence from Asia-Pacific Markets. International Research Journal of Finance and Economics, 58, 121–133. https://doi.org/10.2139/ssrn.2912908

Hamilton J.D.(1994). Time Series Analysis. Princeton University Press, New Jersey, ch. 3, 43-152p. http://www.ru.ac.bd/stat/wp-content/uploads/sites/25/2019/03/504_02_Hamilton_Time-Series-Analysis.pdf

Hanaa, A. L. (2001). Measuring the Performance and Efficiency of the Stock Market Performance in Egypt". Alexandria University Journal,8(2), 1–230.

Hart J., Slagter E., & Dijk D. (2003). Stock selection strategies in emerging markets, Journal of Empirical Finance, 10 (1-2), 105-132. https://doi.org/10.1016/S0927-5398(02)00022-1

Hill, J. B., & Motegi, K. (2018). Testing the White Noise Hypothesis of Stock Returns (SSRN Scholarly Paper No. ID 3001335). https://doi.org/10.2139/ssrn.3001335

Imbens, G. W., & Wooldridge, J. M. (2009). Recent Developments in the Econometrics of Program Evaluation. Journal of Economic Literature, 47(1), 5–86. https://doi.org/10.1257/jel.47.1.5

Kocaarslan, B., & Soytas, U. (2019). Asymmetric pass-through between oil prices and the stock prices of clean energy firms: New evidence from a nonlinear analysis. Energy Reports, 5, 117–125. https://doi.org/10.1016/j.egyr.2019.01.002

Kono, P., Yatrakis, P., & Segal, S. (2011). An Empirical Study of Japanese Market Efficiency: Comparing the Risk-Adjusted Performance of an ETF Portfolio Versus the Topix Index. Global Journal of Management And Business Research, 11(5), 49–54. Retrieved from https://journalofbusiness.org/index.php/GJMBR/article/view/495

Kumar, D. S., & Kumar, L. (2015). Market Efficiency in India: An Empirical Study of Random Walk Hypothesis of Indian Stock Market – NSE Midcap. ZENITH International Journal of Multidisciplinary Research, 5(1), 167–177. Retrieved from https://papers.ssrn.com/abstract=2544459

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics, 54(1–3), 159–178. https://doi.org/10.1016/0304-4076(92)90104-Y

Lakonishok, J., & Vermaelen, T. (1990). Anomalous Price Behavior Around Repurchase Tender Offers. The Journal of Finance, 45(2), 455–477. https://doi.org/10.1111/j.1540-6261.1990.tb03698.x

Lomakin, D. I., Korneev, A. A., Kurgan, A. V., & Machinskaya, R. I. (2018). Risk Disclosure and Deviant Behavior in Adolescents". Russian Journal of Cognitive Science, 5(4), 4–14.

Lucas, R. E. (1978). Asset Prices in an Exchange Economy. Econometrica, 46(6), 1429. https://doi.org/10.2307/1913837

Mirkin, Y. M., Khestanov, S. A., Andryushenko, A. O., & Volkova, A. D. (2015). The aggregate behavior of retail investors in the Russian stock market. Finance: Theory and Practice, 3, 100–106. Retrieved from https://doi.org/10.26794/2587-5671-2015-0-3-100-106

Moscow Exchange. (2020). Moscow Exchange Indices (MOEX Russia Index and RTS Index). Retrieved from https://www.moex.com/en/index/RTSI/archive/#/from=2005-01-03&till=2020-01-10&sort=TRADEDATE&order=desc

Moscow Exchange. (2020a). Moscow Exchange—Blue Chip Index. Retrieved from Moscow Exchange website: https://www.moex.com/en/index/MOEXBC

Moscow Exchange. (2020b). Moscow Exchange—Indices data. Retrieved from Moscow Exchange website: https://www.moex.com/s348

Moscow Exchange. (2020c). Moscow Exchange—Markets: Fact sheets of equity indices. Retrieved from Московская Биржа website: https://www.moex.com/s2184

Moskowitz J., Lasse Y., & Pedersen H. (2012). Time Series Momentum, Journal of Financial Economics, 104 (2), 228-250. https://www.sciencedirect.com/science/article/pii/S0304405X11002613?via%3Dihub. DOI: 10.1016/j.jfineco.2011.11.003

Moustafa, M. (2004). The Weak-Form Efficiency of the United Arab Emirates Stock Market". International Journal of Business, 9, 1–17.

Nekrasova, I. V. (2010). Opredeleniye stepeni effektivnosti rossiyskogo fondovogo rynka na sovremennom etape funktsionirovaniya [Determining the degree of effectiveness of the Russian stock market at the present stage of operation]. Journal of Economic Regulation (Вопросы Регулирования Экономики), 1(2), 5–15. Retrieved from https://cyberleninka.ru/article/n/opredelenie-stepeni-effektivnosti-rossiyskogo-fondovogo-rynka-na-sovremennom-etape-funktsionirovaniya

Nelson, C. R., & Plosser, C. R. (1982). Trends and random walks in macroeconmic time series: Some evidence and implications. Journal of Monetary Economics, 10(2), 139–162. https://doi.org/10.1016/0304-3932(82)90012-5

Omran, S. (2017). Analiz effektivnosti rossiyskogo fondovogo rynka [Analyzing the efficiency of the Russian stock market]. Bulletin of the Russian Economic University named after G.V. Plekhanov, 6(6), 90–95. https://doi.org/10.21686/2413-2829-2017-6-90-95

Onour, I. A. (2009). Testing Efficiency Performance of Saudi Stock Market. Journal of King Abdulaziz University-Economics and Administration, 23(2), 15–2706. https://doi.org/10.4197/Eco.23-2.2

Oprean, C. (2012). Testing the financial market informational efficiency in emerging states. Review of Applied Socio-Economic Research, 4(2), 181–190. Retrieved from https://ideas.repec.org/a/rse/wpaper/v4y2012i2p181-190.html

Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression. Biometrika, 75(2), 335–346. https://doi.org/10.1093/biomet/75.2.335

Podgorny, B. B. (2017). Institutsional'nyye investory rossiyskogo fondovogo rynka: Gabitus i praktiki [Institutional investors of the russian stock market: Habitus and practices]. Russian Journal of Education and Psychology, 8(9), 82–101. https://doi.org/10.12731/2218-7405-2017-9-82-101

Poon, S.-H. (1996). Persistence and mean reversion in UK stock returns. European Financial Management, 2(2), 169–196. https://doi.org/10.1111/j.1468-036X.1996.tb00037.x

Qiang Z., Shu-e Y. (2009). Noise Trading, Investor Sentiment Volatility, and Stock Returns. Systems Engineering — Theory & Practice, 29 (3), 40-47.

Rizvi, S. A. R., & Arshad, S. (2017). Analysis of the efficiency–integration nexus of Japanese stock market. Physica A: Statistical Mechanics and Its Applications, 470, 296–308. https://doi.org/10.1016/j.physa.2016.11.142

Said, A., & Harper, A. (2015). The Efficiency of the Russian Stock Market: A Revisit of the Random Walk Hypothesis. Academy of Accounting and Financial Studies Journal, 19(1), 48–56.

Said, S. E., & Dickey, D. A. (1984). Testing for unit roots in autoregressive-moving average models of unknown order. Biometrika, 71(3), 599–607. https://doi.org/10.1093/biomet/71.3.599

Samuelson, P. (1965). Proof That Properly Anticipated Prices Fluctuate Randomly. Industrial Management Review, 6(2), 41–49.

Schmitt, N., & Westerhoff, F. (2014). Speculative behavior and the dynamics of interacting stock markets. Journal of Economic Dynamics and Control, 45, 262–288. https://doi.org/10.1016/j.jedc.2014.05.009

Semenkova E.(2020). Vliyaniye redkikh sluchaynykh faktorov na dokhodnost' finansovykh aktivov v usloviyakh neopredelennosti [Influence of rare random factors on the yield of financial assets under uncertainty]. National scientific and practical conference "Digital Economy: Trends and Development Prospects", Moscow, October 22–23, 268-272.

Suleiman, M., & Hazem, S. (2013). The Price Efficiency Study of Damascus Securities Exchange". Damascus, Damascus University Journal for Economic and Legal Sciences, 29(2), 151–169.

Svanidze, M., & Götz, L. (2019). Determinants of spatial market efficiency of grain markets in Russia. Global Food Security, 21, 60-68. https://doi.org/10.1016/j.foodpol.2019.101769

Thomas, A. E., & Dileep Kumar, M. C. (2013). Momentum and Contrarian Strategies in the Indian Stock Market – An Evaluative Study. Commerce Spectrum, 1(1), 100–112. Retrieved from https://papers.ssrn.com/abstract=3138630

Worthington, A., & Higgs, H. (2004). Random walks and market efficiency in European equity markets. Global Journal of Finance and Economics, 1(1), 59–78.

Zechariah, A.-Q. (1990). The Efficiency of the Amman Stock Exchange at a Weak Level. Amman: University of Jordan, Faculty of Economics and Administrative Sciences, 50-72.