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"The Evaluation of the Lithuanian Stock Market with the Weak-form Market Efficiency Hypothesis"

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Abstract

The study seeks to provide an extensive research of the Lithuanian Stock Market using the concept of the weak-form market efficiency. There were two research approaches used in the paper – statistical and technical. The first approach was focused on a search for predictability pattern within the value changes of different indexes. The purpose of the technical analysis was to reveal whether existing predictability could be profitability exploited with simple trading rules. The study was based on analyzing three main indexes and therefore provides with conclusions about efficiency in the whole Lithuanian Stock Market, as well as in separate parts of it. In addition to this, the sub-sample analysis was conducted to show an evolution picture of the Lithuanian Stock Market. It appears that the most liquid part of the Lithuanian Stock Market perfectly complies with the weak-from market efficiency, and this tendency seems to be sustainable. An additional and to some extent arbitrary bid/ask assumption was necessary to conclude that the whole Lithuanian Stock Market follows the concept of the weak-form market efficiency (without above mentioned assumption, the whole Lithuanian Stock Markets would appear to be the inefficient one). And finally the research indicates that companies comprising the official list as a whole cannot be said to comply with the weak-form market efficiency despite vanished profitability of trading rules during the last years.

Key words: weak-form market efficiency, efficient market, random walk, statistical analysis, technical analysis, evolution.

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1. Introduction

It is hard to overestimate the importance of the financial markets in a country's economy for the many reasons. First of all, a lot of monetary funds are acquired in the capital markets. Both private and public companies raise debt or/and equity for their everyday operational expenses and business expansion. Secondly, a great number of investors invest their funds in the capital markets. In this case capital markets act not only as wealth treasurers but also provide wealth accumulation. Finally, economic authorities and private agents use information from both stock and bonds markets (which together and determine capital markets) to make their possibly rationale forecasts about forthcoming economic developments and to get a feedback about the activities already conducted. It would be troublesome to deny that capital markets provide with an objective evaluation of a certain country's economy, its perspectives, reveal the problems of certain companies and influence the way economical difficulties can be solved.

It is very important to note that all the roles mentioned in the paragraph above could only be effectively realized in an efficient capital market (Mishkin, 2004). However, the development of the capital markets in the Central and Eastern Europe has started relatively late – in mid 90s - as the consequence of transition from a centrally planned economy to a market based one. Certainly, the Lithuanian Capital Market was not exception. Nevertheless, despite its low liquidity and potential fragility, the importance of the Lithuanian Stock Market is rapidly increasing and gaining more grounds. Still and all the question of achieved market efficiency level in Lithuania and the power to embody all the abovementioned functions remains an opened one and therefore a central one in this research.

The aim of the following research is to prove or deny the hypothesis of the weak-form efficiency in the Lithuanian Stock Market. This is tried to achieve by using both statistical and technical trading tests and exactly such a combination of testing is one of the distinguishing features of this paper since classical efficiency testing and tests of the most commonly used technical trading rules has never been implemented altogether in the same analysis in Lithuania. In addition, the paper sets a task to provide not only with the overall efficiency analysis, but also to give insights about efficiency of certain parts of the Lithuanian Stock Market and this is achieved with usage of three indexes calculated by the National Stock Exchange. Finally, some efforts are given to provide the reader with the conclusions about possible movement of the Lithuanian Stock Market either to efficiency or inefficiency while dividing the original sample in sub-samples and performing the same analysis within them.

The reminder of this paper is organized in the following way. The literature review explaining the theory development and the efficient market concept as well as previous researches on Lithuanian Stock Market efficiency is presented in section 2. A detailed methodological discussion is given in section 3. In the fourth section sample is described while the fifth section reveals some of the main features and key development aspects of the Lithuanian Stock Exchange. Section 6 is devoted for presentation of testing and results, and is followed by the discussion of the results in section 7. The paper is finished with the eighth section where the final conclusions are given.

2. Literature Review

Before starting any scientific study, it might be useful to present a general but short review of the theory being analyzed, to define the main concepts and to see what had been done in the same field of research before this study was written. All that is presented in this section.

2.1. Review of the Theory Development and the Efficient Market Concept

The efficient market theory emerged gradually during the 20th century and is still evolving. The first historically known academic research about subject related to efficient market theory dates back to 1900 when French statistician Louis Bachelier in the opening paragraph of his dissertation paper stated that "past, present and even discounted future events are reflected in market price, but often show no apparent relation to price changes" (as cited in Dimson and Mussavian, 1998, p. 1). Bachelier's discovery later was proved by another great scholar in this field, Paul Samuelson, after extensive research concluding that "… competitive prices must display price changes…that perform a random walk with no predictable bias" (ibid, p. 3). As the Ibbotson and Brinson (1989) point out all the theories developed until 1960s might be called the random walk hypothesis (or a part of efficient market hypothesis, as later will be clarified). The main concern of all the empirical researches made until 1960s was to test whether past price changes might help to predict future price movements. Today such a theory is known as a weak-form of market efficiency.

During the 1960s, academics broadened the random walk theory into a theory of capital market equilibrium, called the efficient market theory (Ibbotson & Brinson, 1989). According to this theory if market prices do not follow patterns, then perhaps current prices already reflect whatever is known about the future (ibid). During this period some disagreements arose about what kind of information should be called "the information already reflected in the price of security". This was the time when a semi-strong form and a strong form of market efficiency had been defined. The semi-strong form of market efficiency postulates that the price of a security reflects not just past prices but all other publicly available information such as balance sheets, income statements, dividend declarations, announcements of earnings, etc. (Malkiel, 1990). And finally the strong form of market efficiency says that absolutely nothing that is known or even might be knowable about a company will benefit an investor – everything should already be fully reflected in the price of that security (ibid.).

A direct result of the development of the efficient market theory was the definition of the efficient market itself. Fama suggested the first definition of the efficient market in 1969: "An efficient market is the market which adjusts rapidly to new information". One year later (in 1970) Fama made his definition even more precise by stating that "a market in which prices always 'fully reflect' available information is called efficient". Malkiel presented a comprehensive definition of the efficient market in 1992:

> A capital market [the same is true for stock market] is said to be efficient if it fully and correctly reflects all the relevant information in determining security prices. Formally, the market is said to be efficient with the respect to some information set if security price would be unaffected by revealing that information to all [market] participants. Moreover, efficiency with the respect to an informational set implies that it is impossible to make economic profits by trading on the basis of that informational set (as cited by Cosma, 2002, p. 5).

2.2. Previous Researches on Lithuanian Stock Market Efficiency

After making extensive literature study in publicly available sources to a student, the author of this research must conclude that there have been only a few studies on Lithuanian Market Efficiency so far. The first attempts to analyze the market efficiency in Lithuania can be found in Klimasauskiene and Moscinskienes's article in 1998. They conduct a research of five blue chip companies, which comprised the official list in Lithuania at that time. The conclusion, however, was pretty inspiring – all five companies – when analyzed individually - had been found to be the weak-form efficient and price changes in all of them seemed to follow the random walk (Klimasauskine and Moscinskiene, 1998)[2].

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[2] The study period is not defined in exactly. However, it is noted that price histories of all companies were analyzed since the first trading session (i.e. 1996). In addition, only active trading sessions were used for the research.

The abovementioned study became a departure point for another study on the market efficiency. This time two scholars – Butkute and Moscinskas - conducted the same type of research[3] in the context of the Baltic countries. Once again a study period coincided with the first trading days of analyzed securities and ended in 1998. It is worth mentioning, that authors also added two more stocks from the Lithuanian Stock Market. The conclusions of this research, when it comes to Lithuania, are pretty much the same as in the previous research: five stocks are found to be the weak-form efficient ones and two newly added do not follow the weak-form market efficiency hypothesis. As authors explain, a rather small number of observations can cause inefficiency within the two newly added companies, and therefore final conclusions should be postponed to the future (Butkute and Moscinskas, 1998). When compared with other Baltic states, the Lithuanian Stock Market seems to settle down in the middle. While all six researched companies in Latvia were the weak-form efficient, Estonia was concluded to have only five out of twelve companies following the random walk and therefore implying the weak-form efficiency (Butkute and Moscinskas, 1998).

When finishing the review of early researches, it is worth stressing that all the studies concentrated on individual-company level. This can be understood, since it was very hard to expect even a bigger part of the Lithuanian Stock Market, as measured by some kind of index, to be the weak-form efficient.

From 1998 to 2002, the study field of market efficiency in Lithuania seems to be forgotten. Only in 2002 Basdevant and Kvedaras returned to the efficiency analysis and provided the readers with one more research of the weak-form market efficiency. As well, as Butkute and Moscinskas, they tried to evaluate the weak-form efficiency of the Lithuanian Stock Market in the context of the Baltic States. It is even more important that their study appeared to be the first attempt to draw some conclusions about the weak-form market efficiency from the index analysis[4]. Moreover, they used dynamic/evolutional analysis of the weak-form efficiency for the period 1997-2002[5],

[3] The sameness is concluded due to the fact that the same testing methodology of the unit root tests was applied in both studies.

[4] These scholars used the LITIN index as a representative of the Lithuanian Stock Market. For more details about this index and its calculation, one should read the *Sample Description* section and the fifth appendix.

[5] For a more detailed description of their methodology, as well its implications to the analysis of this paper, one should consult the "Testing Methodology" section, namely *Limitations and Weaknesses of Methodology*.

and concluded that since the beginning of 2001, the Lithuanian Stock Market appeared to be the weak-form efficient one (Basdevant and Kvedaras, 2002). They also found that Latvia did not demonstrate any clearly expressed tendency for diminishing inefficiency, while Estonia revealed huge drop in inefficiency during the last years of the analyzed period (ibid).

In the end, it can be concluded that the weak-form efficiency testing in Lithuania is rather unexploited sphere and that there is much to be done in this field.

3. Testing Methodology

This part of the paper provides a detailed overview of the methodological tools used in testing the Lithuanian Stock Market efficiency. First of all, a short definition of efficiency is presented and a testable hypothesis defined. Then a random walk theory is put in a formal framework, which is necessary for choosing testing techniques. Later on statistical methods, their calculation and suitability to chosen topic are analyzed. In addition, the paper discusses some of the technical rules also applicable to testing the market efficiency and gives some insights about their implications. The section is finalized with the limitations and weaknesses of the methodology, as the author intuitively understands that no methodology is flawless.

3.1. Definition of Testable Market Efficiency and Hypothesis Formulation

When defining the testable market efficiency, it is worth to recall three basic forms of market efficiency from the Literature Review part. A capital market might be (Fama, 1971):

a) *A weak-form efficient*, if the information contained in former prices is incorporated into present market prices of securities;
b) *A semi-strong form efficient*, if all publicly available information is incorporated into present market prices of securities;
c) And *a strong form efficient*, if all information known to *any* market participant is incorporated into present market prices of securities.

It is no less important to understand, that the above defined efficiency actually falls within one of three broader categories of efficiency. As pointed out by Blake (1990), the capital markets can be defined as being:

a) *Allocatively efficient*. In essence, this means that the capital or securities markets allocate investable resources to highest bidders and in that way assure the most productive use of these resources. In addition, the allocative efficiency causes the prices of securities to equalize the risk-adjusted rates of returns across all securities (i.e. the same level of return should be offered by securities of the same level of risk) (Hall, Urga, 2002).
b) *Operationally efficient*. This indicates that the transaction costs of operating in the market are determined in a competitive way. Or, as Blake says,

"the market operates in a competitive environment with market makers and brokers earning only normal profits (and not monopoly profits) on their activities" (1990, p. 243).

c) *Informationally efficient* which means that the current market price instantaneously and fully reflects all relevant information. If this appears to be the case, then, according to the efficient market hypothesis, the market prices of securities will always equal their fair or fundamental values. Speaking not so strictly, "the prices reflect information to the point where the marginal benefits of acting on information (the profits to be made) do not exceed the marginal costs." (as quoted by Fama, 1991).

As can be easily noticed from the classification provided by Blake, the three forms of the market efficiency recalled at the beginning of this section fall into the informational efficiency category. Therefore it is necessary to stress that this paper focuses exclusively on the informational efficiency testing. In addition, it is worth emphasizing that the forthcoming research is based on the weak-form efficiency analysis. Such a decision was made for several reasons. Firstly, the Lithuanian Stock Market is an emerging one and it is usually believed that the markets in developing countries are not efficient in the semi-strong or the strong form (Mobarek, 2000; Basdevant, Kvedaras 2000, Cosma, 2002). Secondly, it is easy to understand, that if the weak-form market efficiency is found not to hold in the market, all the higher forms of efficiency are certainly not to hold either. However, there is hardly any extensive testing of the overall weak-form market efficiency (with an exception of Basdevant and Kvedaras study which has some different testing specifications) in Lithuania, and therefore testing the weak-form market efficiency seems to be a rational first step which must be implemented. Finally, it should be said that this study concentrates solely on the stock market, since the secondary market for the bonds does exist, but trading there is very infrequent and therefore hardly testable.

After considering all the arguments above, the testable hypothesis should be defined. It is hard to find a generally accepted hypothesis formulating method and therefore the hypothesis formulation by Mobarek (2000), as well as Cosma (2002) is followed:

H0: The Lithuanian Stock Market follows a random walk/is a weak-form efficient;

H1: The Lithuanian Stock Market does not follow the random walk.

As noted in Mobarek's work:

> If the random walk hypothesis holds, the weak-form of the efficient market hypothesis must hold, but not vice versa. Thus, evidence supporting the random walk model is the evidence of market efficiency. But violation of the random walk model need not be evidenced of market inefficiency in the weak form (Ko and Lee, 1991, p. 224).

It is also important to note that this is a more general hypothesis, which was necessary in order to reach the final conclusions at the end of this paper. The more precise ones will be defined in every single statistical test (see below). However, these individual hypothesis are consistent with the general one.

3.2. Formalization of the Random Walk Theory

In order to describe the statistical tests used for the random walk hypothesis testing, the random walk model should be formalized. Let's assume the following equation:

$$P_{t+1} = E_t[P_{t+1} \mid \Omega_t] + e_{t+1} \qquad \textbf{(1),}$$

where P_{t+1} is the price of a given security at the time moment *t+1*; $E\ [P_{t+1} \mid \Omega_t]$ which is the expected price of security at the time moment *t+1,* conditional on Ω_t set of information available in period *t*; e_{t+1} - the expectation or prediction error on security in period *t+1.*

Essentially, the first equation states that the price of security is equal to the sum of the expected price of security and the prediction error. According to the Blake (1990), the prediction error should possess the following properties:

a) Consistency (or unbiasness), implying that $E(e_{t+1} \mid \Omega_t) = 0$ and suggesting that the average of the prediction error is zero;

b) Efficiency, which can be expressed in following equation $E(e_{t+1}e_t \mid \Omega_t) = 0$. The meaning is that the prediction error is uncorrelated with the previous period's prediction error, conditional on the given information set Ω. If this does not appear to be the case then it can be easily proved that efficient market hypothesis fails (see below).

c) Independence expressed in the form $E(e_{t+1}E(P_{t+1} \mid \Omega_t) \mid \Omega_t) = 0$ showing that the prediction error should not be correlated with the expected price.

The prediction error might be interpreted as a news factor or a random shock. Since the news by definition is unpredictable, this interpretation might be said to be valid. In addition, since the news is the only cause for the fundamental value of security to change between the period *t* and *t+1,* an obvious conclusion is that the first equation can be rewritten in the following way:

$$P_{t+1} = P_t + e_{t+1} \quad \textbf{(2)}$$

where e_{t+1} is the prediction error at time moment *t+1* having all the properties presented earlier in this section;

The equation above is known as a random walk or martingale motion (Blake, 1990). It says that since the news is unpredictable, the best estimate of the price on security tomorrow is the price on the same security today (ibid). Besides, it postulates that tomorrow's price will almost certainly differ from today's price; however, since the average of the prediction error is zero, there is no better estimate of tomorrow's price than today's price (ibid).

The second equation gives some easier understandable explanation of the properties mentioned above. For example, the statement that prediction terms are not correlated can be easily seen from the second equation. If the e_{t+1} and e_t would be indeed correlated, for instance, in the following form $e_{t+1} = \rho e_t + v_{t+1}$ (v_{t+1} where is white noise), one could substitute this relationship equation and obtain:

$$P_{t+1} = P_t + \rho e_t + v_{t+1} \Rightarrow P_{t+1} = P_t + \rho(P_t - P_{t-1}) + v_{t+1} \quad (3)$$

$$(P_{t+1} - P_t) = \rho(P_t - P_{t-1}) + v_{t+1} \quad (4)$$

This would show a visible opportunity to forecast both the future price of security P_{t+1} as well as its change $P_{t+1} - P_t$ with past data of prices of securities. Thus, ρ should be zero. It is definitely inconsistent with the weak-form market efficiency to state that past prices can influence future prices, since the information within the past prices cannot produce any news which would change the fundamental value of a security.

In conclusion, the properties of the prediction term, which is equal to price changes (in absolute values) or just return if price logarithms are used (which is the case in this paper), provide some testing guidelines. Namely, the statistical tests presented in the next section will test the properties of the price changes/returns and try to conclude whether the efficiency and consistency properties are valid. If they are not, the random walk hypothesis will be rejected for the Lithuanian Stock Market in the section of results. The technical trading rules (methodology of which is also presented below) will try to detect both linear and non-linear patterns within the movement of residuals and then profitability of detected trends will be examined.

3.3. Statistical Tests and Their Implications

As noticed in the literature, the autocorrelation tests are most commonly used as the first tools for detection of randomness. In addition, most of the studies in Lithuania done on individual stocks also used autocorrelation tests and therefore this test was chosen to be the presented and implemented first of all.

As one recall, the residuals (value changes in indexes) under the random walk hypothesis are not correlated. Formally: $E(e_t e_k) = 0$ and t$\neq$k. One of many ways to estimate the autocorrelation coefficients is defined by the following formula (Cosma, 2002):

$$\rho(k) = \frac{\operatorname{cov}(r_t, r_{t-n})}{\sqrt{\operatorname{var}(r_t)\operatorname{var}(r_{t-n})}} = \frac{\operatorname{cov}(r_t, r_{t-n})}{\operatorname{var}(r_t)}$$

where $\operatorname{cov}(r_t, r_{t-n})$ defines covariance between the current return and by *n* days lagged return , $\operatorname{var}(r_t), \operatorname{var}(r_{t-n})$ defines variation of current return and lagged by *n* days return respectively, *n* itself defines the length of the lag.

Before moving forward, one clarification must be done. This study uses the logarithms of index values[6]. In addition, it is approximated that: $Ln(a) - Ln(b) = Ln\frac{a}{b} \cong \frac{a}{b} - 1 = r_a$, meaning that price changes are, in essence, the same as the returns (Hellstrøm, 1998, p. 15). Therefore, further on the changes in prices and returns should be treated synonymously both in text and in formulas and should not trigger any additional confusion.

One of methodological decisions, when autocorrelation analysis is concerned, is the choice of the lag length. As Gujarati notes “Although there are tests about the

[6] The reason for such a choice is given in the Sample description section.

maximum length of the lag to be used in calculations, in practice lags up to one-third of the sample size are generally used. But this matter is very often subjective" (1995, p. 716). Since the sample comprises of 874 observations, one third of the sample would be obviously too much. Therefore an arbitrary/subjective number of 12 lags was chosen. When choosing the optimal length of the lag, longer lags were also analyzed, but since there were hardly found any significant autocorrelations beyond the 12th lag, the length was limited to this number.

In order to find whether estimated individual coefficients of autocorrelation significantly differ from zero, the significance test was performed. Also the following hypotheses were defined:

H0 $\hat{\rho}_k = 0$

H1 $\hat{\rho}_k \neq 0$

As Gujarati notes: "Bartlett has shown that if a time series is purely random, that is, it exhibits white noise, the sample autocorrelation coefficients are approximately distributed with zero mean and variance 1/n, where *n* is the sample size" (1995, p. 717). Then following the properties of standard normal distribution, the interval of [-1.96*1/n;1.96*1/n], is the acceptance interval of the null hypothesis. If the individual autocorrelation coefficient falls outside the specified interval, the individual autocorrelation is then concluded to be significant and therefore the general hypothesis of random walk is rejected.

In order to get a bit more general view of autocorrelation, the joint hypothesis of no significant autocorrelation was formulated and tested:

H0 $\hat{\rho}_1 = \hat{\rho}_2 = ... = \hat{\rho}_k$

H1 $\hat{\rho}_1 \neq \hat{\rho}_2 \neq ... \neq \hat{\rho}_k$

For testing the formulated hypothesis, the Q statistic test was used. To calculate the abovementioned statistic, the following formula was chosen:

$$Q = n\sum_{k=1}^{n} \hat{\rho}_k^2 ,$$

where $\hat{\rho}_k$ is at k lag estimated autocorrelation coefficient and *n* is the length of the lag.

According to Box and Pierce, the Q statistic is approximately distributed as the chi-square distribution with m degrees of freedom (as note by Gujarati, 1995, p. 717). Therefore, the testing procedure was as in the classical hypothesis testing case: if the calculated value of the Q statistics exceeds a critical value specified by chi-square distribution at the chosen level of significance (which is always 5% in this paper), one can reject the null hypothesis that all coefficients of autocorrelation are zero and conclude that indexes do not follow the random walk.

After the individual and overall autocorrelation had been tested, a test of economical significance was implemented. The economical significance in this paper is understood in the same way as a determination coefficient, and this definition is taken from Campbell, Lo and MacKinlay (p. 66, 1995). In essence, the autocorrelation coefficient can be found while modeling the following regression and using the method of ordinary least squares:

$R_t = \alpha + \alpha_1 R_{t-1} + e_t$, where α_1 and represents the abovementioned coefficient, and e_t represents the "white noise".

When the coefficient α_1 is squared, it becomes the determination coefficient, showing how much of total variation of the R_t can be explained by the variation of the R_{t-1}.

In order to test a bit more informative economical significance, the following regression can be modeled:

$R_t = \alpha_0 + \alpha_1 R_{t-1} + \alpha_2 R_{t-2} + ... + \alpha_n R_{t-n} + e_t$, where n is the length of the lag, and e_t stands for the "white noise".

The prerequisite for qualifying for such a regression was the condition of the autocorrelation coefficient being individually significant. After all the significant coefficients of the autocorrelation, were added, the determination coefficient was calculated using the formula below:

$$R^2 = \frac{\sum (\hat{R}_t - \overline{R})^2}{\sum (R_t - \overline{R})^2},$$

where the numerator shows explained variance by the regression and the denominator represents the total variance, and $\overline{R}$ is the average return for the analyzed period.

Another way of analyzing the autocorrelational patterns within the changes of indexes is a runs test. The distinguishing feature of this test is its non-parameterness That is, while implementing this test, one does not need to make any assumptions about the distribution from which the observation were drawn (Gujarati, 1995). Besides, as noted by Fisher and Jordan:

> There is a potential problem, however, when one uses a correlation coefficient to evaluate the possibility of independence in particular series. This problem arises because correlation coefficients can be dominated by extreme values. That is, an extremely large or extremely low value or two in the series can unduly influence the results of the calculation used to determine the correlation coefficient. To overcome this possible shortcoming, some researches have employed the runs test (1991, p. 625).

In order to implement the runs test, one has firstly to count the number of runs within a certain series. The run is defined as a sequence of observations having the same sign (the absolute values are not important at this moment). After every change of sign, the number or runs increases by one (and starts, of course from one) and this way is computed until the end of the analyzed series is reached. For example, if one observes a series in which the observations change signs in the following way ++----+-+++---+, he or she can conclude that there were 7 runs. It is clear that index values do not change their signs, since the price of security cannot be negative. However, one should remember that this study focuses on analyzing the price differences, and in this case a negative price change (price decrease) is a common thing.

Since the runs test focus on the presence of autocorrelation, the null hypothesis and the alternative hypotheses are the same as in the case of the common autocorrelation test, namely:

H0 $\hat{\rho}_1 = \hat{\rho}_2 = ... = \hat{\rho}_k$

H1 $\hat{\rho}_1 \neq \hat{\rho}_2 \neq ... \neq \hat{\rho}_k$

The essence of testing is also pretty the same as in the case of autocorrelation tests. However, the main question in the test of runs is whether the number of runs obtained from a given series is consistent with the number of runs, which one would expected to find in a strictly random series (Gujarati, 1995). In order, to answer this question the mean and the variance should be computed using the formulas below (ibid):

$$E(k) = \frac{2n_1 n_2}{n_1 + n_2} + 1 \quad \text{and} \quad \sigma_k^2 = \frac{2n_1 n_2 (2n_1 n_2 - n_1 - n_2)}{(n_1 + n_2)^2 (n_1 + n_2 - 1)}$$

where *n* is the total number of observations, n_1 is the number of “+” symbols, n_2 is the number of “-“ symbols and *k* the number of runs.

The testing procedure is also similar to the one used in autocorrelation tests. Specifically, if the number of runs obtained in an analyzed series lies within the interval $[E(k) \pm 1.96\sigma_k]$, one cannot reject the null hypothesis with 95% confidence. Otherwise, the null hypothesis is rejected implying that the analyzed series does not follow the random walk pattern.

As one might recall from the formalization of the random walk, the residual (which in essence represents changes in prices) should be white noise or in other words a totally random variable. In addition, the statistical theory postulates that the distribution of random occurrences should conform to a normal distribution (Fisher & Jordan, 1991). The better the approximation of the normal distribution pattern can be reached by changes of indexes, the more random the series itself can be concluded, and the more efficient the market can be called. Therefore a natural desire to test for normality was implemented in the paper.

In order to present the comprehensive analysis of the normality both graphical and analytical methods were used. The graphical method in this paper is defined as analysis of graphs (individual and comparative) and is limited to noticing whether the form of distribution is visually similar to the normal distribution or not. The analytical method is understood as analysis of some parameters common for the normal distribution and in that way helps to get a more objective view of the distributional pattern when the one obtained from just comparing the graphs.

It should be clear that a graphical method essentially does not have any methodological concerns and therefore it will be moved directly to the description of the analytical methodology. In order to determine the properties of an obtained distribution, the two following statistics – skewness and kurtosis - were calculated using the formulas suggested by Gujarati (1995):

$$Skewness = \frac{[E(R_t - \overline{R})^3]^2}{[E(R_t - \overline{R})^2]^3} \text{ and } Kurtosis = \frac{E(R_t - \overline{R})^4}{[E(R_t - \overline{R})^2]^4},$$

where all the variables are defined as in previous tests.

In the presence of the normal distribution, one would expect to have skewness equal to zero, and kurtosis equal to 3. If skewness is found to be less than zero, it means that the classical pattern of the normal distribution is right skewed, while a positive value of skewness indicates a left skewed form of the classical distribution form[7]. In short it can be noted, that skewness reveals the symmetry of the distribution. If kurtosis is found to be less than 3, it is called platykurtic and if it is found to be higher than 3, it is called leptokurtic. In essence, a platykurtic pattern indicates a fat or short-tailed form implying higher than necessary variance of examined series, while leptokurtic pattern indicates a slim or long-tailed form suggesting higher than usual concentration about the mean[8]. If the kurtosis is found to be 3, the pattern is known as mesokurtic.

In order to see whether the calculated values for skewness and kurtosis do not significantly differ from the values specified by the theory of statistics, the significance tests were performed. The first step when calculating test statistics is defined by the formula below and essentially represents the process of normalizing residuals (Davidson and MacKinnon, 1993, p. 568):

$$e_t \equiv \frac{\hat{u}_t - \hat{\mu}}{\hat{\sigma}},$$

where $\hat{\mu}$ denotes the sample mean of the $\hat{u}_t$'s, and $\hat{\sigma}$ denotes the sample standard deviation of the $\hat{u}_t$'s.

After obtaining the normalized residuals, the test statistics for skewness and excessive kurtosis are defined respectively (ibid):

$$t_{skewness} = \frac{1}{\sqrt{6n}} \sum_{t=1}^{n} e_t^3 \text{ and } t_{kurtosis} = \frac{1}{\sqrt{24n}} \sum_{t=1}^{n} (e_t^4 - 3)$$

As noted by Davidson and MacKinnon, "each of these test statistics will be asymptotically distributed as N(0,1) under the null hypothesis of normality and each of their squares will be asymptotically distributed as χ^2 with one degree of freedom" (ibid). Therefore the following hypothesis can be formulated:

H0 *Skewness=0* H0 *Kurtosis=3*

H1 *Skewness* $\neq$ *0* H1 *Kurtosis* $\neq$ *3*

And if the calculated statistics exceeds the critical value of the chi-square with 95% confidence and one degree of freedom, the null hypothesis of normality is rejected, as well as the null hypothesis of the random walk.

Moreover, Davidson and MacKinnon note that "since it can be shown that these two statistics are independent, the sum of their squares will be asymptotically

[7]The shapes of right and left skewness in graphical form can be seen in the first appendix

[8]Both platykurtic and leptokurtic form and their comparison with the normal distribution can be found in the first appendix

distributed as $\chi^2(2)$" (ibid, p. 568-69). In other words, the statement above leads to a well-known Jarque-Bera test, which was also performed in this research. The JB statistics, as noted by Gujarati, is obtained in the following way (1995, p. 143):

$$JB = n[S^2/6 + (K-3)^2/24],$$

where S represents skewness and K represents kurtosis.

As proved by Jarque and Bera, in large samples the JB statistics follows the chi-square distribution with two degrees of freedom. After formulating the hypothesis:

H0 $JB=0$ and

H1 $JB \neq 0$,

once again the classical testing procedure of significance was implemented: if the calculated JB statistics exceeds the critical value of chi-square with 95% confidence, the null hypothesis is rejected, as well as the null hypothesis of the random walk.

3.4. Technical Analysis and Chosen Tests

This section should be started by clearly distinguishing between two main branches of technical analysis: charting and mechanical rules. As noted by Neely "charting involves graphing the history of prices over some period – determined by practitioner – to predict future patterns in the data from the existence of past patterns" (1997, p. 24). It comes from the definition that this method is highly exposed to subjectivity and is hardly testable, since skill and judgment abilities of a certain technician play central role in finding these patterns (ibid). Therefore this paper does not put any further considerations about the ways of testing charting-based strategies.

On the other hand, simple technical rules do possess a feature of quantification and for this reason are tested in the following sections. As defined by Fabozzi: "Mechanical [technical] rules are those in which no consideration is given to any factor other than the specified technical indicators[9]… The overlying principle of these strategies is to detect changes in the supply of and demand for a stock [security] and capitalize on the expected changes" (1995, p. 217). However, the mechanical rules, as the technical analysis as whole, still have a factor of subjectivity. This factor is especially noticeable when the time lags for search of past patterns must be defined. The remaining subjectivity can be explained by the fact that most of the technical

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[9] And these technical indicators are explicitly defined by mathematical functions.

analysis does not have any solid theoretical foundation, and therefore subjective factor cannot be totally avoided (Isakov and Hollistein, 1998).

It also worth emphasizing that technical analysis has one distinguishing feature if to compare with the statistical tests – technical rules can detect non-linear patterns of movements in price changes and therefore can provide with a more sophisticated analysis than the estimates of statistical tests where all the analyzed relationships are restricted to the linear patterns[10]. Moreover, the technical analysis section concentrates on examining whether the predictive power detected by the statistical analysis can be put into profitable use in a costly trading environment. As Hudson, Dempsey and Keasey put, the forthcoming section of the technical analysis is "*directly concerned with the weak-form efficiency* of technical trading rules rather than the distributional properties of stock [index] return" (1996, p. 1128) and for that reason should be treated as a very important part of this paper helping to make final conclusions.

Before starting to define technical rules one more important note should be made. Even if a certain technical trading strategy is found to be profitable, it still may be consistent with the weak-form market efficiency. As noted by Hellstrøm: "this [profitable trading strategy] may not contradict the EMH if new useful methods are not immediately assimilated by the global trading community" (1998, p. 6). However, if one can see the growing profitability of a discovered strategy and also notice that strategy being publicly available, the conclusion of the weak-form inefficient market must be accepted. Since only the most common technical rules are analyzed in this paper, any found profitability will mean the failure of the weak-form market efficiency.[11]

In order to implement technical rules, it is necessary to define where these technical rules will be applied. Since this paper is concerned with the index analysis, the technical rules will be tightly related to index investment. More precisely, it will

[10] Certainly, this comment is applicable only to this paper, since the statistical tests employed here indeed reveal only linear patterns. However, this paper in no means states the limitations of statistical techniques as a whole.

[11] At this stage it is very important to define the term *profitable*. In this research, profitability will be treated synonymously with the phrase *excessive returns*. In other words, the author uses the word *profitable* to say that the analyzed technical strategy would generate higher return than the B&H-based strategy. This note is made since it may appear rather confusing the see the negative return of a certain technical strategy, and at the same time the find such return called profitable.

be assumed that a certain index can be replicated and therefore value changes of an index will be treated as changes of a corresponding portfolio.

In addition, three different portfolios will be used as research tools: long-cash, long –short and buy and hold (hereafter, B&H). In the case of the long-cash portfolio after obtaining a buy signal from the mechanical rule, a long position in the index is initiated and when a sell signal is given by the same mechanical rule, the position is closed, and the proceeds are held in cash. Quite similarly can be described the long-short strategy. The only difference is that after receiving a sell signal the buy position is closed and the short position is opened, that is the index portfolio is shorted. The reason for including this strategy is the higher level of comprehensiveness of the performed research. Finally, the buy and hold portfolio is a benchmark, according to which the conclusions about market efficiency are drawn – if any strategy can outperform the B&H portfolio, the index can not be said to demonstrate the weak-form market efficiency (Shachmurove and Klein, 2001). In other words, no excessive returns (which are essentially the difference between the B&H portfolio and any other portfolio based on the mechanical rule) are allowed if the weak-form market efficiency is assumed to hold.

As noted above in this section, the paper tries to examine whether any of these active strategies can be profitable within the investment environment. Therefore some comments about the trading costs and other adjustments are necessary to mention. In all cases trading costs per transaction are assumed to be 0.35% of the total capital invested.[12] Not less important it is to stress, that when the LITIN-G and the LITIN indexes are analyzed, additional variable associated with trading costs is introduced – a bid/ask premium[13], which should help to diminish the departure from the reality to the lowest possible extent. For the LITIN-G the bid/ask premium is assumed to be 2.5%, while for the LITIN – 1%. Since the LITIN-10 does not generate any profits in majority of situations even without the bid/ask spread, no assumptions for this index were made.

The first mechanical rule analyzed in this paper is a moving average rule. The key idea behind this strategy is that "the moving averages are supposed to capture trends and leave aside the "noisy" part of evolution of prices" (Isakov and Hollistein,

[12] This is the lowest commission fee an investor can expect to obtain in Lithuania.

[13] The author strongly emphasizes that a bid/ask spread and a bid/ask premium are not the same. For further discussion about this difference, as well as for the argumentation why certain values for the bid/ask premiums where chosen, one should read the sixth appendix.

1998, p. 1). In order to add some more clarification it can be said that all moving average strategies are associated with support and resistance. According to ABG Analytics Equity Trading Systems (thereafter ABG) “if the current price of a certain security is above its moving average level, then that particular level of the moving average is considered to be ‘support’. Conversely, if the current price of a certain security is below its moving average, then that particular moving average level is considered to be ‘resistance’”. Also it is assumed that if a security price is near to its support level, the price of that security is much more likely to rise than to fall. On the other hand, if the security price is almost the same as its level of resistance, the probability that the price of that security will fall is higher than opposite (ibid).

The methodological concerns arise when the moving average rule must be specified. This study will analyze only simple-moving-average-based strategies and will leave out a weighted, as well as an exponential moving averages. As pointed out by Neely, the length of the moving average reveals whether the moving average reflects short- or long-run trends (1997). In addition, “the academic literature has shown that the best results were obtained when the short moving average is one day but has not reached any conclusion on the length on the long period.” (Isakov and Hollistein, 1998, p. 4). Following the arguments above, the trends of the short-run will be presented by one day moving average, while 10-day and 50-day will stand for the intermediate-run and 100-day and 200-day will represent the long-run trends. The reasoning for the other “windows” of moving averages rests on the fact that these terms are the most common in academic researches as well as in the real world.

The trading rule is as follows: “the moving average rule gives a buy signal when a short moving average is greater when the long moving average; otherwise it gives a sell signal” (Neely, 1997, p. 29).

The second mechanical rule analyzed in this paper is a filter rule also called a “trading range break” rule. Alexander originally defined this rule in 1961:

> If the price of a security moves up at least y%, buy and hold the security until its price moves down at least y% from a subsequent high, at which time simultaneously sell and go short. The short position is maintained until the price rises at least y% above a subsequent low, at which time one covers the short position and buys. Moves less than y% in either direction are ignored (as cited in Fama, 1970, p. 394-95).

The idea behind this rule is once again quite clear – it seeks to identify the trends within the movement of securities. However, since there had not been any solid theoretical background for this rule, the choices of filter size and the recent extreme range were rather subjective and depended on the author himself. In this paper four different filters were chosen with the smallest of 1% and the largest of 4% (other two were 2% and 3%). The justification for the 1% filter is the fact that it would be hard to test the long-short portfolio with lower filter, since the roundtrip costs would equal 0.7% (0.35%x2) and therefore no profit could be expected. The largest filter was chosen according to the fact that changes higher than 4% were very rare within the indexes and therefore this testing would not differ from the B&H strategy. When it comes to finding extremes – minimum and maximum values of indexes – a five-day period was chosen following the test performed by Neely (1997). Another argument for this would be that 5 days is one week and can be treated as rather long period for news to arise and change indexes.

3.5. Limitations and Weaknesses of the Methodology

Certainly no study is perfect and therefore some limitations and weaknesses should be revealed. The most discussable weakness (or the one which should be discussed at the beginning of this study) is related to the fact that this study applies a classical framework for testing market efficiency, which according to some authors, is not very a suitable one for the emerging markets. For example, Basdevant and Kvedaras in their article analyzing the weak-form efficiency of three Baltic States argue that "traditional methodology defined by Campbell, Lo and MacKinlay (1997), Malkiel (1989), as well as Fama (1991) describe the market efficiency as rather static characteristic and define the testing procedure as testing efficiency versus inefficiency" (2002, p. 3). In addition, Hall and Urga point out that such a statistical testing would cause the early inefficiency to bias the results of estimation and conclude that the market is inefficient simply because of past inefficiencies (2002). In other words, the authors of both studies try to state that the evolution of market also should be taken into account in a form of modified properties of usual statistical tools when market efficiency is tested in the emerging markets.

However, the author of this paper still finds meaning for applying classical efficiency tests for the Lithuanian Stock Market (which still is treated as an emerging one). The logics come from the conclusion of Basdevant and Kvedaras in their study that Lithuanian Stock Market: "is clearly approaching the weak-form efficiency, although not as steadily as the Estonian one, but rather with some repeating smaller turbulences. The last of them [happening from April to October] is actually not significant" (2002, p. 13). Moreover, from the provided analysis in Basdevant and Kvedaras' paper, it becomes apparent that Lithuanian Stock Market entered the phase of the weak-form efficiency at the beginning of 2001. Since the analysis of this paper starts exactly from the beginning of 2001, no strong inefficiency bias in final results should be expected. In addition to this, the analysis in this paper takes into account to sub-samples of the whole period and in that way tries to detect possible increase in inefficiency and its bias to overall results. In addition, the application of the classical efficient market methodology in Lithuania (no matter that static one) can be hardly found in any publicly available sources, and that certainly adds value to chosen approach. Nevertheless, the critics provided by Basdevant and Kvedaras cannot be forgotten, since their conclusion about the market efficiency is reached with the LITIN index, while this study tries to evaluate the Lithuanian Stock Market efficiency using two more indexes.[14]

Another weakness, which might be found in this term paper, relates to an index investing concept. Since this study focuses on the Lithuanian Stock Market evaluation while using different indexes, it is necessary to remain consistent throughout the whole research and apply technical trading rules to the indexes. Exactly for that reason index investing might suffer from criticism since it is not possible to realize such an investment option in the emerging Lithuanian Stock Market, and one might raise doubts about the following conclusions from these tests. Such a criticism can be mitigated to some extent by pointing out the fact that basically an individual investor[15] can easily replicate two of three indexes. This is because the LITIN and the LITIN-10 comprise a small number of liquid stocks. When it comes to the LITIN-G, the criticism is more rational; however, since this index represents the state of the whole market, exclusion of it could be hardly justified. And even the conclusions with some arbitrary background should be valuable.

[14] For more detailed index description, one should read the *Sample Description* section and the third appendix.
[15] The same might be said about an institutional investor. However, such investors might encounter some more difficulties due to the problem of market depth, which is limited in Lithuania.

To add, the study suffers from one more drawback of the Lithuanian Stock Market – the absence of quickly implementable short selling option. Once again this weakness can be found in the part of the technical analysis of this study. In author's opinion, the short selling option can add some power of "trend catching " and in that way give some additional insights about the market efficiency. Besides, since the ordinary buy-and-sell strategy is covered with the long-cash portfolio, the results are not dominated or based only on a negotiable assumption of the study.

4. Sample Description

This section of the paper discusses sources of data for the research, gives some arguments for the sample choice and reasons creation of the sub-samples. In addition, indexes – the main representatives of the Lithuanian Capital Market – are analyzed and their choice as well as suitability for the analysis is justified. The section ends with revealing some of shortcomings of the sample and of the methods describing the sample (i.e. indexes) in order to provide the readers with some precautions when making any conclusions in the analytical part.

4.1. Data Collection and Sample Choices

The index-level data was collected from the National Exchange of Lithuania (hereafter NSEL). Specifically, the data series ranging from the beginning of 2001 until the end of 2002 were received from the Juozas Brigmanas, the director of the market analysis department within the NSEL, while the rest of data was obtained from the official home page of the NSEL. All that was said above eliminates any doubts about the reliability of data analyzed, and this issue will not be discussed any further.

The study concentrates its analysis on the period continuing from January 1st, 2001 until the June 14th, 2004. The starting date was chosen for several reasons. As it has been already discussed in the section named *Weaknesses and Limitations of the Methodology*, the study analyzing the evolution of the Lithuanian Stock Market efficiency concluded that approximately from the beginning of 2001 the Lithuanian Stock Market became the weak-form efficient one. In order to see whether found efficiency is sustainable and whether different analysis methods can give the same conclusion, the beginning point of 2001 has been chosen. Secondly, as noted by the NSEL: "Until 29 December, 2000, the indices were calculated on the basis of weighted average share price of the trading session and from the beginning of January 2001, they are computed according to the closing price". Therefore the choice of longer period including the years before 2001 might have resulted in methodological bias and ended up with conclusions influenced by the methodological aspects rather by changes in the weak-form market efficiency. When it comes to discussing the ending data, it can be said that this date (namely, June 14th, 2004) was the last day before the writing of analytical part had been started.

It is also worth mentioning that the whole sample consists of 874 observations when the values of the indexes are considered and obviously of 873 observations when value changes in the indexes are analyzed. In addition, only daily changes in indexes are analyzed in order to have the possibly longest time series. Not less important is the fact that research was also done with two sub-samples. These two sub-samples were created while dividing the original sample in two equal parts[16]. Since 873 cannot be equally divided by two, the first sub-sample consists of 437 observations, while the second has 436 observations. The sub-sample decision was taken in order to see possible evolution of the market either towards efficiency or inefficiency and to give some additional insights about the overall period. Moreover, since during the second sub-sample all indexes demonstrated extraordinary growth (all of them increasing by more than 100 percent[17]), additional interest of testing a bullish market for the efficiency arose.

4.2. Representatives of the Sample – Indexes

In order to extract some conclusions about the weak-form market efficiency, indexes as analysis tools were used. As mentioned in the methodological section, this study uses indexes as overall measures for the market state and in that way tries to make conclusions about the level of efficiency in the Lithuanian Stock Market.

One of the goals of this research was to provide a comprehensive analysis of the efficiency. Since it is rational to expect to find inefficiencies of some extent in emerging markets, the author has chosen to analyze three different indexes at the same time, and in that way not only to conclude whether the Lithuanian Stock Market is efficient or not, but also in case of found overall inefficiency to see whether separate parts of the Lithuanian Stock Market represented by different indexes can be named to be the efficient ones.

The first index under consideration is the LITIN-G. This index is a capitalization-weighted price index[18], which comprises all the listed securities[19] and reflects the general price level and dynamics of the Lithuanian equity market. Since the largest companies have the greatest influence on the changes in the index, the

[16] All descriptive statistics of the analyzed samples can be found in the second appendix.
[17] The dynamics of all the indexes, as well as their growth during the whole period and during the certain sub-samples can be found in the second appendix.
[18] The formulas how all indexes can be calculated are given in the third appendix.
[19] The number of listed securities fluctuated about 42-50 during the analyzed period.

LITIN-G is the best indicator of the overall situation of the state's economy (*official NSEL website*). Therefore the conclusions from this index are the most important ones mainly because they give a general picture of the weak-form efficiency in the Lithuanian Stock Market.

Rather similar index to the LITIN-G is the LITIN. This index is also acapitalization-weighted price index. However, it only includes the stocks from the official list.[20] Not less important is to note that the LITIN included from 6 to 8 stocks during the analyzed period and these companies can be interpreted as being the most prominent companies in Lithuania[21].

The last index, which is analyzed within the paper, is the LITIN-10. Unlike the two indexes before, this one is a market price index solely (that is, the size of the enterprise in terms of capitalization is not essential). The TOP-10 shares most actively traded at the National exchange during the last half a year form a base of this index. This base is revised semi-annually and new shares are added or removed following several criteria: capitalization of free float, share turnover on the central market, quotation frequency, and weight of a certain security. In essence, just mentioned criteria ensure that the LITIN-10 always reflects ten most actively traded companies and therefore is sometimes referred as an index for speculators and medium term investors.

4.3. Shortcomings of the Sample

In order to evaluate the results in a most objective manner, the shortcomings of the sample should be discussed. Firstly, the data about indexes suffers from usage of closing prices. Of course, a weighted average of the index value during the trading session would be a better measure but since such a data is not provided by the NSEL, this flaw could not be eliminated.

Secondly, as noted on the official website of the NSEL, all indexes do not reflect the changes in turnover of securities. This might result in bias to some extent when evaluating the index movement, since even a few small transactions on high

[20]There are two worth knowing lists in Lithuania – an official list and a current list. The main difference between these two lists is the disclosure requirements, which are certainly more strictly to the companies in the official list.

[21] This statement can be justified by the fact that all companies included in the Baltic list are companies from the official list (*NSEL official website*).

capitalization companies can have rather noticeable influence on a certain index, and especially its closing price.

Thirdly, none of the analyzed indexes allow for any adjustments related to distribution of dividends (*official NSEL website*). Surely this is a mentionable flaw, but one should not overestimate its impact on the weak-form efficiency tests. As mentioned by Mobarek: ”Many researchers confirm that their conclusions remain unchanged whether they adjusted their data for [the distribution of] dividend or not” (2000, p. 9). Therefore this shortcoming is not treated as a very influential one.

5. Short Description of the Lithuanian Stock Market and its Development

This section provides the reader with a very short review of the Lithuanian Stock Market, its main features and the development of the market. Such a description is necessary in order to understand the study more deeply and to define the term of an emerging market in more detailed way.[22]

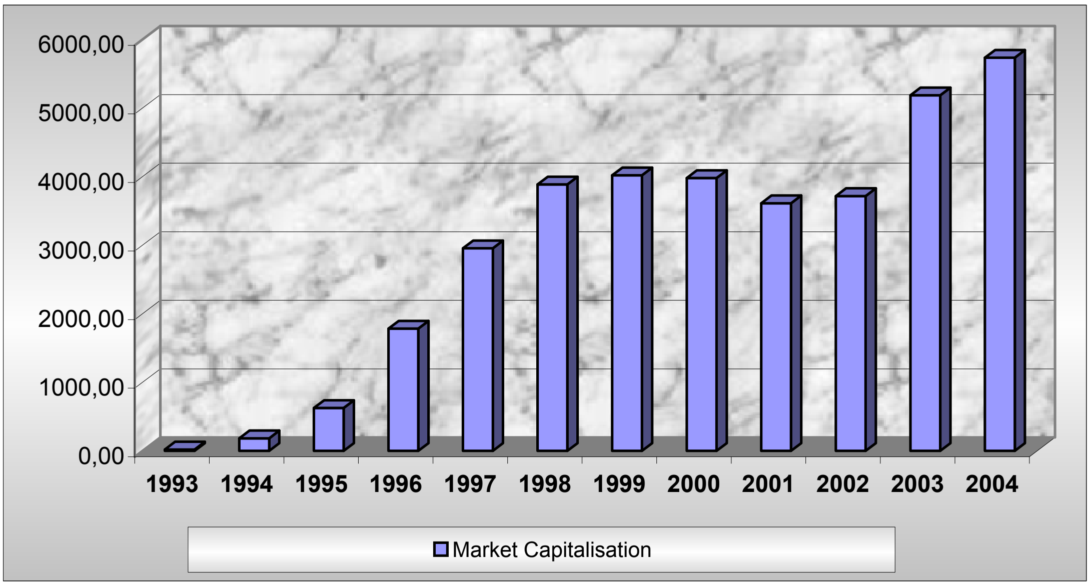
As in all transition economies in the Eastern and Central Europe, the first stages of the market economy are related to mass privatization and creation of market structures. One of the most important market structures in the context of mass privatization was a Stock Exchange. The grounds for the Exchange establishment were laid down in 1992 when resolution of the Government of the Republic of Lithuania *On the Establishment of the Securities Commission and the National Stock Exchange of Lithuania* was adopted (*Official NSE website*). However, it took almost one year before the first trading session took part (that happened on September 14th, 1993). In addition, it is worth mentioning that during the first trading sessions only shares were traded (as the need for such a trading was the primary goal for setting the Exchange). However, not much time passed before the trading of the Government Securities was introduced. It actually happened in August of 1994. Several years later (in 1997) the trading of corporate bonds was implemented and from that time some new types of securities - depository receipts and subscription rights - were also added. By the end of June 2004, all in all 2365 trading sessions had been carried out.

It is also important to emphasize an evolution of the trading process. Until 1995, trading took place only once a week, later twice a week, and only from December 1996, daily trading of all the listed securities was finally realized. Year 1996 also was the year when official indexes were started to calculate[23]. At the current moment trading in securities at the National Stock Exchange is fully computerized and dematerialized. There are two types of deals - central market trades and negotiated deals – which may be concluded at the Exchange. It is also important that trading on the central market is based on the principle of the order-driven market, i.e. the transaction price depends on the submitted orders to buy and sell securities.

[22] As it is an obvious difference, for example, between the Lithuanian Stock Market and the Russian Stock Market, despite the fact that they both fall under the category of emerging markets. The difference can be most clearly seen when capitalizations of different markets are compared.
[23] However, the LITIN was started in 1997, and LITIN-10 was introduced only in 1999.

Finally, in order to see the Lithuanian Stock Market size, the capitalization of it and its dynamics are given in the graph below.

Graph 1 *Capitalization of the Lithuanian Stock Market in 1993-2004 in euros*



Source: Report "National Stock Exchange of Lithuania – the Past and Future Decades" (2003)

When analyzing the dynamics, it should become apparent that the market capitalization has an upward trend, which seems to be rather strong during the last two years and can partially be attributed to the fact of the EU accession, which has attracted quite a lot foreign investors to Lithuania. In addition, it is worth stressing that Lithuanian Stock Market capitalization is calculated as the sum of all listed securities, including the Government bonds which is not always the case when it comes to calculation of the market capitalization in other countries (Butkute and Moscinskas, 1998).

When finalizing this section, it may be valuable to mention that on May 28, 2004, OMHEX, Northern Europe's largest securities market operator, and the Lithuanian State Property Fund closed the transaction, whereby OMHEX purchased 44.3 percent of the shares of the NSEL and 32 percent of the shares of the Central Securities Depository of Lithuania and after obtaining some more shares from other investors became the main shareholder of the Lithuanian Stock Exchange (*Official NSEL website*). This acquisition should definitely add up to the development of Lithuanian Stock Market and hopefully increase its efficiency.

6. Testing and Results

The 6th section of this paper presents an extensive discussion of results obtained while applying the tests defined in the *Testing Methodology* section. This section begins with the statistical tests, which analyze the distributional patterns of three different indexes and ends up with the discussion of results from the mechanical rules, which try to evidence the profit opportunities in the real investment environment.

6.1. Statistical Tests

This section provides with the results obtained from the statistical analysis. At the beginning the results of autocorrelation and economical significance tests are reported. Later some conclusions about the weak-form market efficiency in Lithuania are drawn from the runs test. The section is finalized with a discussion about the normal distribution and whether it is apparent or not within the changes of indexes.

6.1.1. Autocorrelation and Economical Significance Tests

The section of results begins with an autocorrelation and economical significance analysis. In author's opinion these tests are helpful in making preliminary conclusions and later on giving some background to the preceding tests. Before presenting the results, it should be one more time stated that autocorrelation tests help to determine whether any predictability in successive index returns is possible to detect. The results of this test are presented in the table below.

Table 1 *Rates of Autocorrelation for the Different Indexes*

Lag in trading sessions												
INDEX	1	2	3	4	5	6	7	8	9	10	11	12
The whole period												
LITIN-G	**0.11***	**0.15***	**0.08***	**0.07***	0.03	-0.01	0.05	**0.08***	0.06	0.05	0.04	0.05
LITIN-10	**0.08***	0.07	-0.02	0.01	0.02	0.03	0.01	0.04	0.03	0.01	0.05	0.04
LITIN	0.05	**0.07***	0.06	**0.09***	0.01	-0.02	**0.08***	0.04	-0.03	0.02	0.01	-0.01
The first sub-sample												
LITIN-G	0.03	**0.16***	**0.10***	0.06	0.04	0.01	0.01	-0.05	-0.01	-0.04	0.02	0.01
LITIN-10	-0.01	0.02	-0.08	0.01	0.03	0.00	0.01	-0.06	0.04	0.00	0.01	0.01
LITIN	0.02	0.03	0.07	**0.11***	-0.03	-0.06	0.04	-0.01	**-0.11***	-0.02	-0.05	-0.01
The second-subsample												
LITIN-G	**0.14***	**0.11***	0.03	0.06	0.00	-0.05	0.05	**0.14***	0.09	**0.09***	0.04	0.05
LITIN-10	**0.14***	**0.09***	0.02	-0.01	0.00	0.04	0.00	**0.11***	0.01	-0.01	0.08	0.05
LITIN	0.06	0.08	0.02	0.05	0.02	-0.02	0.09	0.06	0.04	0.01	0.06	-0.04

Source: data from the NSEL and the author's calculations

** denotes significantly different from zero autocorrelation coefficients at 5% confidence level*

Several very important conclusions might be drawn from present numbers. First of all, it is easy to notice that the LITIN-G, representing all listed securities in the Lithuanian Stock Market, demonstrates the most frequent serial correlation. As can be seen, the first four lags when the whole sample is considered differ significantly from zero. Besides, as sample analysis shows, high level of autocorrelation for the LITIN-G is sustainable during the whole period; however, the first sub-sample surprisingly demonstrates uncorrelated returns from the first lag perspective. Moreover, four autocorrelated lags in the second sub-sample as compared to two in the first sub-sample indicate slightly decreasing randomness of the Lithuanian Stock Market.

The LITIN-10, which comprises most actively trading shares, shows a strong tendency of being efficient. During the whole period only the first lag might have influenced future price changes significantly. However, keeping in mind the fact that the Lithuanian Stock Market is only emerging one this result is very promising.

However, the negative news for this index comes from performed sample analysis. It is obvious from the given table that while being totally random and therefore the weak-form efficient during the first sub-sample, the market, as measured by this index, becomes much more predictive in the second period (having the first and the second lagged values influencing future returns). Nevertheless, it seems that the overall market efficiency evaluated by this index does not suffer too much from the increased non-randomness during the second period.

Interesting conclusions also arise from the LITIN index. As can be seen from the numbers, this index has some statistically significant and therefore predictive components (namely, the second, the fourth and the seventh lagged values) during the whole period. On the other hand, the second sub-sample obviously indicates substantial improvement in efficiency (no predictive components were found). Therefore this index might be concluded as moving towards the weak-form efficiency.

Since it is very hard to evaluate market efficiency from individually statistically significant coefficients, the Q statistic test was also performed in order to make some more generalized conclusions and evaluate the overall autocorrelation. The results might be seen in the second table.

Table 2 *Q Test for the Different Indexes*

	The whole sample (12df)	The 1st sub-sample (12 df)	The 2nd sub-sample (12 df)
LITIN-G	**58.21***	**21.36***	**36.41***
LITIN-10	16.57	5.88	**23.42***
LITIN	**25.34***	16.86	13.95

Source: data from the NSEL and the author's calculations

* denotes the cases when Q calculated exceeds Q critical and therefore means rejection of non-autocorrelation hypothesis.

The Q statistic, which can also be interpreted as joint hypothesis that all autocorrelation coefficients are simultaneously equal to zero, helps to clarify the picture of the Lithuanian Stock Market efficiency a bit. This test clearly indicates that the LITIN-G is autocorrelated as well as during the whole sample as during the sub-samples and therefore the random walk hypothesis for this index is rejected at 5% significance level.

As noticed in the previous analysis of the individual significance of the autocorrelation coefficients, the Q test approves the fact that if the market efficiency would be measured by the LITIN-10, the Lithuanian Stock Market would be concluded to be the weak-form efficient. In addition, from the presented results, it is one more time obvious that the LITIN-10 becomes non-random during the second sub-sample and therefore might threaten the achieved weak-form efficiency.

Finally, it is worth mentioning that very unusual results come from the LITIN – the last index under consideration. It appears that despite being random during sub-periods, it becomes non-random when measured against the whole period. At this moment it is truly hard to say what causes such a result. Most probably, the results are influenced by some outliers and whether this is the case should be revealed by other tests. Now it can only be said that it is rather hard to see clear direction in which the market is currently moving.

On the whole, both individual and overall correlation tests reveal one anomaly known by the name of *a small-firm effect* (Mishkin, 2004). They key point of this anomaly is that it normally takes more time to incorporate all the new and relevant information into prices of smaller securities and therefore one might expect to find longer lags of that incorporation. In addition, it should be clear that if these lags were found to be regular and predictable, one might create strategies profiting from them. And this surely would deny the weak-form market efficiency.

As can be seen from the first table, the LITIN-G has a much longer series of significant lagged values influencing the future movements of this index. Moreover, on the average the LITIN-G demonstrates 0.07 autocorrelation, while both the LITIN-10 and the LITIN show only 0.03 and 0.04 average autocorrelation respectively during 12 periods.[24] Not less important it is to note, that autocorrelation coefficients during the first and the second lags are obviously higher in the case of the LITIN-G. After mentioning these reasons, there is little surprise to see that Q test concluded the LITIN-G to be non-random (i.e. with predictable patterns) during the analyzed period while the LITIN-10 was random (i.e. unpredictable) during the same sample and the LITIN was random during the two sub-samples where the LITIN-G also demonstrated non-randomness. It obvious that the LITIN-10 comprised of ten most liquid stocks and the LITIN calculated from eight also frequently traded stocks can much more rapidly adjust to the new information and hardly leave any chances for profit from the lagged incorporation of information.

Nevertheless, one should be careful to make conclusions about revealed phenomena and remain reserved while attributing it to the weak-form inefficiency. It might seem that a liquidity factor might be largely responsible for the small-firm effect. In addition, there are several other factors mentioned for example by Mishkin – large information costs of evaluating small firms, inappropriate measurement of risk for small-firm stocks, less stringent disclosure requirements – which might be the causes of much slower the LITIN-G adjustment to new information (2004).

The final thoughts on autocorrelation test can be expressed during the evaluation of the economic significance process. As noted by Cambel, Lo and Mackinlay (1997) economic significance might be measured by the determination coefficient (R^2), which essentially shows how much of total variation can be explained by a certain lag value and is calculated simply as the square of a corresponding autocorrelation coefficient. After calculations[25] were done, it becomes obvious that in the best case the variation of the LITIN-G can be described by individual autocorrelation coefficient at most by 2.22 percent, and on average only by 0.55 percent. Not surprisingly, the level of explained variation by a single

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[24] The average autocorrelation coefficient was calculated using the absolute values of individual autocorrelation coefficients. Since the emphasis was put on significance, not only on the values of autocorrelation coefficients, such an average seemed to be more informative and less distortive if individual autocorrelation coefficients for a certain index would change signs frequently.

[25] The calculations are not reported in a separate table, since they can be easily obtained by an interested reader from the first table. Also it is worth mentioning that this part analysis was done only for the whole period.

autocorrelation coefficient falls when the LITIN-10 and the LITIN indexes are considered. For example, the highest predictable variation in the LITIN-10 is only 0.62 percent if the first autocorrelation coefficient would be used for the prediction and on average only 0.16 percent is explainable by individual lagged values. The results are relatively similar for the LITIN - the maximum explainable variation is 0.83 percent (when using the fourth lagged value) and average is only 0.24 percent.

It is obvious that results from simple economic significance tests (where explained variation is analyzed only by individual autocorrelation coefficients) are not sufficient to make any serious and finalized conclusions about the existence of the random walk among these three indexes. Therefore following the idea developed in Gjolberg and Strøm study, some additional regressions were modeled (1991). The main feature of these additional regressions is inclusion of several lagged variables at the same time. More precisely, the inclusion of all significantly important lags reported in the first table. Therefore these two regressions for the whole sample were run:

$R_t = R_{t-1} + R_{t-2} + R_{t-3} + R_{t-4} + R_{t-8} + e_t$[26] (for the LITIN-G),

$R_t = R_{t-2} + R_{t-4} + R_{t-7} + e_t$ (for the LITIN),

where R_{t-n} represents return at the n lag, and e_t residual of the regression, having zero mean and constant variance ("white noise" assumption)[27]

The results are summarized in the third table

Table 3 *Coefficients of the Regressions for the LITIN-G and the LITIN indexes*

Index	**Coefficients of regression**						
	α_0	α_1	α_2	α_3	α_4	α_5	R^2
LITIN-G	0.00	**0.08***	**0.13***	0.05	0.04	**0.07***	0.04
	β_o	β_1	β_2	β_3	-	-	R^2
LITIN	0.00	0.06	**0.08***	**0.07***	-	-	0.02

Source: data from the NSEL and the author's calculations

* denotes statistically significant coefficients at 5% confidence level

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[26] As have already been mentioned in methodology section, $R_t = \frac{P_t - P_{t-1}}{P_{t-1}} = \frac{P_t}{P_{t-1}} - 1 \cong Ln\frac{P_t}{P_{t-1}}$ when changes in P_t are relatively small which is the case in this study. Therefore there is only minor difference between running a regression expressed in returns and a regression expressed through ln functions. However, the former is much more convenient and easier to understand.

[27] The regression associated with the LITIN-10 is not created since there is only one significant autocorrelation coefficient meaning that the R^2 estimated by such a regression would equal the determination coefficient already discussed in the paragraph above.

From the results shown in the table it becomes apparent that even when all individually significant lagged values are included, the total explained variance of the indexes seems to be very small: 4 percent for the LITIN-G, 2 percent for the LITIN and only 0.64 percent for the LITIN-10. Although one might argue that there is quite large multicollinearity between the different lags[28] and therefore presented models are not valuable, such criticism can be denied for several reasons. First of all, in the presence of multicollinearity, the traditional determination coefficient might be unexpectedly high (Gujarati, 1995). That, in essence, means an opportunity for overvaluation of explainable variance, not vice versa. Secondly, the multicollinearity does not bias variables (they are still best linear estimates) and for that reason they still show right-direction influence. And finally, the author also analyzed regressions without insignificant variables and other forms of possible regressions, and only presented ones reached such a relatively high R^2.

While concluding this section of the analytical part, some remarks should be made. It is obvious that individual autocorrelation tests and overall autocorrelation test do prove statistically significant predictability in indices. The strongest predictability was demonstrated by the LITIN-G, while the LITIN-10 seemed to be the most unpredictable/random out of three, leaving the LITIN in middle. However, after performing economic significance test, the found results certainly shed some doubts on the statistical significance and their practical importance in forecasting returns, since the explained variation by these statistically significant lags are extremely low.

6.1.2. Runs Test

Another way to test for autocorrelation within the changes of three indexes is the runs test. The distinguishing feature of this test is its non-parameterness which, as extensively discussed in the methodology section, helps to make conclusions about autocorrelation without making any assumptions about the distribution from which observations were drawn (Gujarati, 1995). The obtained results from the runs test are reported in the following table.

[28] And exactly existing multicollinearity in the equations is responsible for some of the regression coefficients being significant individually, but insignificant when taken in combination with other significant autocorrelation coefficients.

Table 4 *Number of the Runs and Their Randomness for the Different Indexes*

Index	The whole sample	The 1st sub-sample	The 2nd sub-sample
LITIN-G	384* **(406;463)**	202 **(198;239)**	183* **(190;230)**
LITIN-10	410 **(407;464)**	223 **(198;239)**	188* **(194;234)**
LITIN	397* **(408;466)**	214 **(197;237)**	184* **(194;235)**

Source: data from the NSEL and the author's calculations

* denotes the rejection of the random walk hypothesis[29]

The first conclusions will be drawn for the LITIN-G index. It should be obvious from the table that the LITIN-G during the whole period has not followed the random walk and therefore the hypothesis of the weak-form market efficiency cannot be accepted for this index. In addition, the provided data reveals that despite being random during the first sub-sample, the LITIN-G loses its randomness during the second sub-sample. This can be interpreted rather straightforward – the non-randomness of the second period seems to be responsible for the whole non-randomness within the LITIN-G. Therefore it may be safe to conclude that when the LITIN-G is considered as a measure for the market efficiency, the Lithuanian Stock Market seems to move towards inefficiency. In order to finalize analysis of this index it is worth stressing that in both - the whole sample and the second sub-sample - samples there were fewer runs than suggested by purely random series (this can be noted from the given intervals below the number of observed runs). According to Gujarati, this actually shows positive autocorrelation within the residuals (1995). In other words, the prices change too seldom and therefore trends in price changes of the LITIN-G can be identified (which in turn means possibility to design profitable trading strategies).

The finding of either negative or positive autocorrelation leads to overreaction and underreaction interpretations. More specifically, positive autocorrelation suggests that the market adjusts to the news gradually (not rapidly!) and these adjustments are in the same direction, while negative correlation reveals more frequent than necessary price reversals meaning that market overreacts to the news (Fabozzi, 1995). Therefore seeing positive autocorrelation in two cases out of three in LITIN-G index suggests that the Lithuanian Stock Market has a tendency of underreaction.

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[29] For the full description of rejection process of the random walk hypothesis, one should review the *Testing Methodology* section.

It is also worth mentioning that this finding contradicts the conclusion reached by cognitive psychologists in the USA, saying that: “In general, people tend to overreact to extreme events. People tend to react more strongly to recent information; and they tend to heavily discount older information.” (Fabozzi, 1995, p. 220). Therefore it can be carefully stated that investors in Lithuania might be a bit more cautious than their counterparts in the USA, and therefore price adjustments take longer. It is also possible that this phenomenon can be explained by liquidity reasons – for example, high bid-ask spreads might induce delayed reaction by investors since a wrong interpretation of the news might be too expensive.

Quite different conclusions are reached when the LITIN-10 is analyzed with the runs test. According to the reported numbers, it becomes apparent that the LITIN-10 does follow the random walk during the 2001-2004 period. However, one should notice the rejection of randomness for the value changes of the LITIN-10 during the recent years. Nevertheless, the non-randomness is not so influential as in the case of the LITIN-G index, and therefore Lithuanian Stock Market measured by this index should be concluded as being random and therefore the weak-form efficient.

Finally some thoughts on the LITIN should be expressed. It can be noticed that the LITIN does not follow the random walk during the whole period of analysis. Even though this index demonstrates the weak-form efficiency during the first sub-sample, the second sub-sample seems to have much stronger influence on overall efficiency performance of the LITIN index since reported non-randomness results in the non-randomness during the whole period.

Also noticeable is the fact that the LITIN acts in the same way as the LITIN-G (see table 4). This should not come at surprise, because the LITIN –G includes all the eight stocks listed in the LITIN, and the LITIN is also a capitalization-weighted index. However, this tendency of two indexes moving together in an efficiency sense is important since it shows that even companies from official list as a whole cannot be concluded to follow the random walk. Of course, this is a tentative conclusion and therefore some further research is needed. Since this paper analyses efficiency only from index perspective, such a researched was not performed.

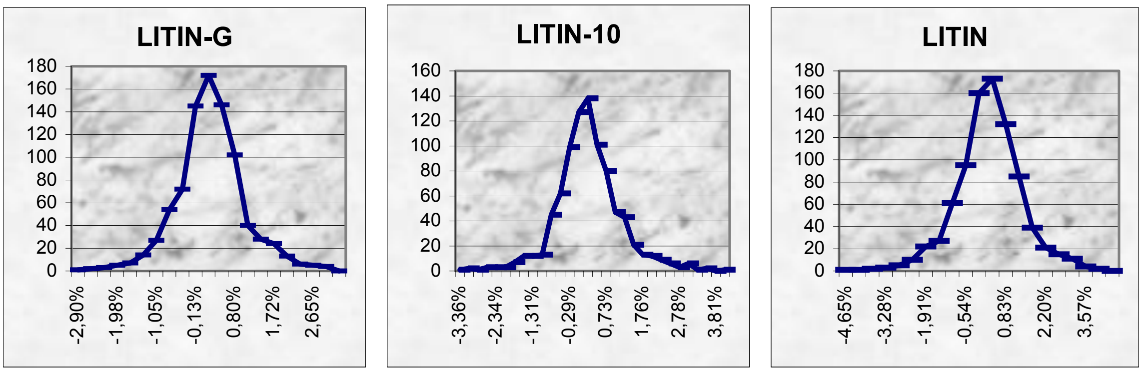
In conclusion, the overall picture of the Lithuanian Stock Market revealed by the runs tests looks to be rather clear. Both the LITIN-G and the LITIN indexes do not follow the random walk, and therefore the weak-form market efficiency hypothesis cannot be accepted for these indexes. However, the most actively traded stocks representing the LITIN-10 do follow the random walk implying that at least some piece of the Lithuanian Stock Market is the weak-form efficient. On the other hand, discovered autocorrelation during the second sub-sample in the LITIN-10 casts some doubts on whether the revealed efficiency of this index is a sustainable one. These doubts become even stronger when the LITIN-G and the LITIN examples are considered – both these indexes seem to lose their randomness during the most recent period, i.e. the year 2003 and part of the year 2004. Finally, the presence of strengthening positive serial correlation (which can be seen from decreasing number of runs when the first and the second sub-samples are compared to one another) shows too slow and not accurate incorporation of information into the prices of stocks lending an argument for increasing inefficiency justification. Nevertheless, the departure from acceptance intervals for the random walk hypothesis is not high and this once again raises the discussion between statistical importance and practical aspects of exploiting these departures profitabily.

6.1.3. Tests of the Normal Distribution

One of the ways, which was discussed in the *Methodology Section*, to test the weak-form market efficiency is to see whether the changes in indices follow the normal distribution. Basically, as found in most analysis, there are two most common ways to assess the presence of the normality – a graphical method and analytical method which includes analysis of certain numerical data. Both of them are presented in this section.

The easiest way to get a tentative impression of the normality is to look at the graphs of residuals and to see whether drawn pattern does show any similarity with the form of the normal distribution. As can be seen from the following graphs, they do represent the familiar classical structure of the normal distribution. However, this impression, as mentioned above, is only tentative and therefore might be misleading. Exactly for this reason the analytical part is also presented.

Graph 2 *Distribution Patterns of Changes of the Different Indexes*



Source: data from the NSEL and the author's calculations

There are several quantitative methods to test for the normality of distribution. In this paper skewness and kurtosis analysis is performed as well as more generalized conclusions drawn from the Jarque-Bera test (hereafter, the JB test) of normality. The measures for just mentioned variables are presented in the fifth table.

Table 5 *The Main Characteristics of the Normal Distribution for the Different Indexes*

Index	The whole sample			The first sub-sample			The second sub-sample		
	S	*K*	*JB*	*S*	*K*	*JB*	*S*	*K*	*JB*
LITIN-G	**0.09****	2.84	**2.20***	**0.06****	1.62	35.06	**0.02****	3.38	**2.59***
LITIN-10	0.23	2.09	38.09	**0.16****	1.39	48.96	0.27	2.57	8.56
LITIN	-0.35	3.86	44.95	**-0.21****	3.41	6.16	-0.52	4.71	72.40

Source: data from the NSEL and the author's calculations

where S denotes Skewness, K denotes Kurtosis, and JB denotes the calculated value of the Jarque-Bera's statistics;
* denotes cases where the null hypothesis of the normal distribution within a movement of a certain index cannot be rejected at 5 percent significance level;
** denotes statistically not different from zero value of skewness (at 5 percent significance).

As it is become a common practice in this paper, the analysis will begin with the LITIN-G. It can be seen from the table that both skewness and kurtosis seem not to be departed far from their original values when the whole sample is considered. However, statistical tests do indicate that only skewness does not show significance departure from zero and therefore the LITIN-G index can be said to be symmetric during the analyzed period. When it comes to kurtosis, the null hypothesis of kurtosis equaling 3 is rejected. Therefore, when evaluating normality only be these variables, the LITIN-G appears not to follow the normal distribution during the whole period. It is important to note that the LITIN-G is found to be left skewed implying more positive changes than negative ones during the whole period and the analysis of kurtosis reveals platykurtic pattern suggesting fatter than necessary form of the normal distribution.

When it comes to the sub-sample analysis (the graphical forms of which are presented in fourth appendix for all indexes), it is necessary to point that symmetry of the LITIN-G increases during the second period (that is approaches zero). However, the kurtosis dynamics shows a reversal from platykurtic form to leptokurtic form and in both cases appears to be significantly different from what is considered to be acceptable for the normal distribution.

Even more interesting and rather surprising results come from the JB test, which uses skewness and kurtosis for getting the JB statistics. The test suggests that the LITIN-G does follow the normal distribution during the whole period and therefore essentially can be concluded to be the weak-form efficient (despite the fact, that kurtosis during this period is significantly different from 3). It hard to give valid explanation for different results aroused from the individual skewness and kurtosis analysis, and the jointed analysis. However, at this stage the JB test is felt to be more accurate (mainly for its incorporation of skewness and kurtosis at the same time), and therefore the conclusions from this test are taken into account more seriously than the ones from individual tests.

Before ending discussion of the JB test, it is necessary to point out that this test does indicate the improvement of the weak-form efficiency – the null hypothesis of normality using this test is rejected for the first sub-sample while is accepted for the second one (see the fifth table).

The story with LITIN-10 is slightly different when individual skewness and kurtosis analysis is performed for the whole sample. In the case of the LITIN-10 neither skewness nor kurtosis is within the allowed limits of statistical theory and therefore the normality hypothesis while using these individual variables is surely rejected for the LITIN-10.

As can be seen from the table, the overall left skewness found in the LITIN-10 is due to the gradual increase of asymmetry during the two sub-periods (this is easily noticeable when these two samples are graphically compared in the fourth appendix). It is also worth noticing that the LITIN-10 was symmetric during 2001-2002 and lost its symmetry only during the last years. Since the LITIN-10 becomes more left skewed than before, meaning that positive changes in index outnumber the negative ones, such a finding can be attributed to a substantial increase in the value of the LITIN-10 during the second sub-period.

Kurtosis during the sub-periods did increase and for that reason can be concluded to approach the required value of 3. Despite the good tendency, the overall kurtosis variable is also significantly different from the one found in the normal distribution and still remains platykurtic. Therefore the LITIN-10, while using measures for skewness and kurtosis, can be defined as the index having the non-normal distribution pattern. It is also important to note, that the JB test concluded exactly the same – the LITIN-10 did not appear to have the normal distribution during the whole sample, as well as during the sub-samples (see the fifth table).

The final index under consideration is the LITIN index. This index at first sight provides with quite different conclusions when individual parameters for skewness and kurtosis are considered. After recalling results from the analysis above with two other indexes, it is rather unusual to observe the LITIN index being right skewed. The tendency of the right skewness appears to be sustainable – in all samples the value for skewness is lower than 0 – and therefore this finding is even more unusual. In addition, one can also notice from the given table that the LITIN index has always been leptokurtic and this was not the case in earlier index analysis. Besides, the graphical analysis of the LITIN during the whole period (the graph can be seen at the beginning of this chapter) and the graphical analysis of the LITIN during the sub-samples (the graph can be seen in the fourth appendix), did not indicate any observable bias from zero which should be the case when relatively high negative skewness is found. All this lead to reanalyzing the original data set and discovering that there were two extraordinary large negative changes in the value of the LITIN (-6.26% and –7.38% in the first and the second sub-samples respectively). The adjusted parameters for the whole sample and for the sub-samples can be found in the following table.

Table 6 *Skewness, Kurtosis and JB Statistics for the Different Indexes*

Index	**The whole sample**			**The 1st sub-sample**			**The 2nd sub-sample**		
	S	*K*	*JB*	*S*	*K*	*JB*	*S*	*K*	*JB*
LITIN	-0.35	3.86	44.95	**-0.21****	3.41	6.16	-0.52	4.71	72.40
LITIN(ad.)	**-0.06****	2.28	19.29	**0.01****	2.48	**4.99***	**-0.14****	2.33	9.39

Source: data from the NSEL and the author's calculations

where S denotes Skewness, K denotes Kurtosis, and JB denotes the calculated value of the Jarque-Bera's statistics;

* denotes cases where the null hypothesis of the normal distribution within a movement of a certain index cannot be rejected at 5 percent significance level;

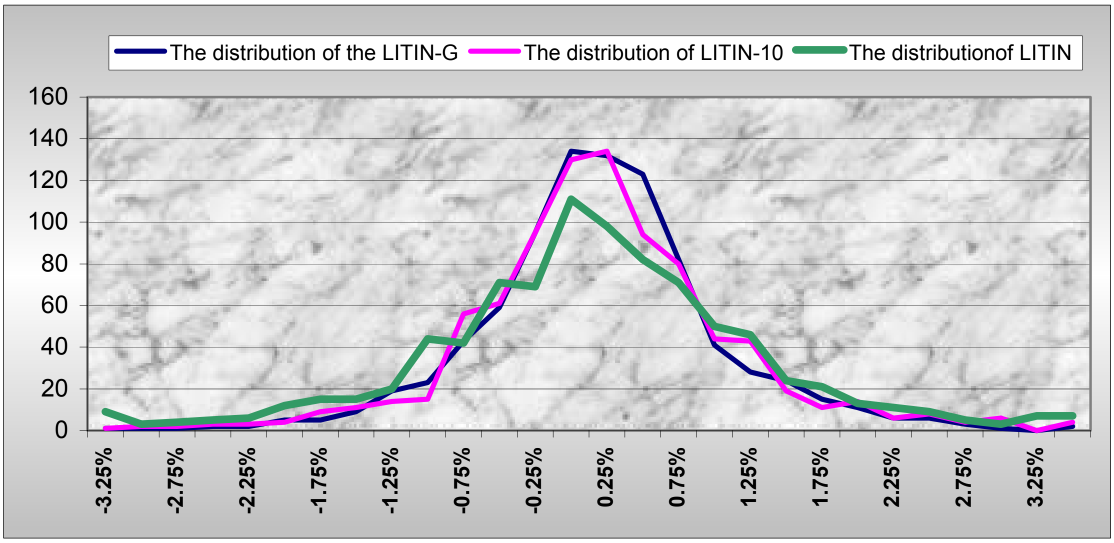
** denotes statistically not different from zero value of skewness (at 5 percent significance).

One of the most noticeable things after adjustment is that the LITIN index appears to be symmetric both during the whole period and intermediate periods (and in that way very similar to the LITIN-G which should be the case). Symmetry could be reported only once if the original data would be analyzed and skewness not significantly differing from zero would be found in the first sub-sample. In addition to this, one can notice that the extent of the right skewness falls substantially and even a reverse in the first sub-sample can be noticed. Secondly, after removing outliers from the original data set one can notice that the LITIN now seems to reveal the same pattern of platykurticness as the other two indexes. Finally, it should be said that results for the JB test differ slightly. More specifically, the LITIN seems to be normally distributed during the first sub-sample and lose its normality during the second sub-sample indicating decreasing randomness and increasing predictability.

After discussing the results for slightly adjusted data, it should become apparent that this test despite large samples definitely suffers greatly from outliers and the reported results, especially when no adjustments were made, should be taken with cautious and reserved conclusiveness. In addition, it should be clear that this test can only give some insights but not to make final conclusions about the weak-form market efficiency.

Before ending this section, it is valuable to perform a comparative analysis of the normal distribution of all indexes at the same time. For the purpose of more comprehensive analysis, the distribution of changes of the analyzed indexes during the whole sample is presented in the third graph.

Graph 3 *Distribution of Changes of the Different Indexes*



Source: data from the NSEL and the author's calculations

It is pretty clear from the graph that all indexes do show more or less the same pattern of distribution. According to the performed analysis, the LITIN-G resembles the normal distribution form and for that reason other two distributional graphs of the LITIN-10 and the LITIN can be easier evaluated. While the LITIN seems to be more than necessary platykurtic (fat or short-tailed) and therefore not normally distributed (this also is proved by numbers of kurtosis in the fifth table), the LITIN-10 gives an impression of being asymmetric (skewed to the left too much) and that is why violating the assumption of the normal distribution (also such graphical impression is justified by the numerical coefficients of skewness). After noticing that, it is rationale to conclude that both the LITIN-10 and the LITIN do not follow the random walk during the whole analyzed period and cannot be said to demonstrate the weak-form efficiency (and this is justified by the corresponding the JB statistics in the fifth table). In this case, only the LITIN-G index qualifies for the randomness assumption (using the conclusions from the JB test, as was discussed above) as well as for the weak-form efficiency.

One more interesting conclusion can be drawn from the fact that all indexes exhibit noticeable bias to the left (left skewness). This discovery of asymmetry clearly indicates that changes in indexes in more cases are positive than negative and once again indicates longer runs of up than down. In addition, it is important to note that symmetry is much more common for all analyzed indexes than mesokurticness. More specifically, one can find statistically the significant symmetry in 7 out of 9 cases[30] while kurtosis cannot be reported in any of samples analyzed.

This section can be concluded with a comparison of developed stock market in the USA, in which, according to Campbell, Lo and MacKinlay: "At short horizons, historical returns show weak evidence of [negative] skewness[31] and strong evidence of [positive] excess kurtosis[32]" (1995, p. 16)[33]. It is obvious that in the Lithuanian Stock Market situation is quite opposite – here at the short horizons one can observe positive skewness and negative excess kurtosis. However, this is only an indication of

[30] This conclusion is made while assuming that adjusted data set for the LITIN index is more reliable and informative due to the reasons discussed previously in the paper.
[31] Negative skewness is the one, which is below zero (from here comes the word "negative"). Using the terminology of the paper, the negative skewness is the same as the right skewed normal distribution.
[32] Excessive kurtosis is defined by Campbell, Lo and MacKinlay as a departure from value of 3 (which should be found in the presence of the normal distribution). If the difference is more than zero, it is called "positive excess kurtosis", otherwise it is called "negative excess kurtosis" (1995, p. 16).
[33] The remarks in brackets within the quotation marks indicate tendencies for stock indexes.

difference, and can hardly be interpreted as a drawback. The theory requires symmetrical distribution with a mesokurtic pattern and deviations to any of the side (if they are significant) reject the null hypothesis of the random walk.

6.2. Technical Rules

This section provides with the results obtained from testing simple technical trading rules. At the beginning, the results for the moving average are presented, and later the filter rule testing and the results of it are reported.

6.2.1. Moving Average Tests

As mentioned in the methodological part, technical rules are trying to catch trends within the past data of indexes and extrapolate these trends into the future for the reason of earning higher returns than those of holding the market portfolio. As one of these attempts can be named the moving average rule the profitability of which in the context of the Lithuanian Stock Market is tested in this section.

The discussion begins with the main index of the Lithuanian Stock Market – the LITIN-G. The results obtained while using the different moving averages are concluded in the following table.

Table 7 *Returns of the Different MA Strategies for the LITIN-G Index*

Portfolio type	MA 10	MA 50	MA 100	MA 200
Long-cash	182.07%	180.85%	117.87%	127.93%
Long short	304.94%	292.63%	113.27%	104.30%
Long- cash*	112.54%	165.59%	96.19%	119.34%
Long-short*	130.95%	249.94%	72.40%	88.55%
Long-cash**	-70.32%	79.15%	-6.23%	67.32%
Long-short**	-67.53%	**136.37%**	-17.39%	43.97%
B&H	102.80%	102.80%	102.80%	102.80%

Source: data from the NSEL and the author's calculations

*denotes portfolios adjusted for the transaction costs;
**denotes portfolios adjusted for the transaction costs and the bid/ask premium

The first conclusion, which becomes obvious from the table, is that all portfolios with all moving-average based strategies exceed the BH benchmark, when no transactions costs are considered. That is this strategy perfectly works in the theory world. The situation only slightly changes when transaction costs are introduced for the LITIN-G. One can still find 5 out of 8 strategies beating the market. In addition, there are no clear conclusions which of the MA strategies are more sensitive to the transactions costs, since with an exception of the MA 100, all others do demonstrate profitability.

However, it should be remembered that due to its specific, the LITIN-G is exposed to high the bid/ask spread and therefore introduction of it practically (with an exception of one portfolio) eliminates any profitable strategy based on analyzed moving averages. That gives an argument for the efficient market hypothesis; however, with some arbitrary background.

When comparing different MA strategies for the LITIN-G, it is easy to notice that short selling portfolios are more profitable with in intermediate-run (MA 10, MA 50), while buy portfolios are better for long-run (MA 100 and MA 200).

The comparison of the different sub-samples[34] does show the LITIN-G is approaching the weak-form market efficiency or reveals the increasing usage of this trading system. As can be noticed from the tables, if only the transaction costs were added, during the first sub-sample all the portfolios do exceed the benchmark. This is not the case during the second sub-sample. Actually, there are only two portfolios slightly exceeding the BH portfolio. Even more important is to note that when the bid/ask premium is introduced, in the first sub-sample one can still find 4 out of 8 MA strategies being profitable while in the second sub-sample there are none.

The results for the second index under the consideration – the LITIN-10 – are presented in the eighth table. The table is different from the one for the LITIN-G in that sense that no the bid/ask premium-adjusted portfolios are included.

Table 8 *Returns of the Different MA Strategies for the LITIN-10 Index*

Portfolio type	MA 10	MA 50	MA 100	MA 200
Long-cash	98.14%	136.94%	111.87%	137.05%
Long short	77.68%	162.08%	81.37%	125.48%
Long- cash*	28.92%	113.36%	92.13%	134.58%
Long-short*	-24.40%	113.34%	48.67%	120.04%
B&H	135.65%	135.65%	135.65%	135.65%

Source: data from the NSEL and the author's calculations

*denotes portfolios adjusted for the transaction costs;

The story starts pretty the same as before – without exposing oneself to the real investment environment, one could earn some extra money from using the moving-average based strategies while enjoying costless trading. Nevertheless, it is important to stress that only two strategies generate excessive returns – a substantially lower number if to compare with other indexes. One more distinguishing feature to be noticed is that when transaction costs are incorporated, the LITIN-10 index seems to

[34] The results for the sub-samples for the LITIN-G index (as well as for all others) are presented in the fifth appendix.

comply with the weak-form market efficiency perfectly. In essence, none of the analyzed MA strategies provide with the profit opportunities and therefore gives a strong argument for the randomness within the movement of the LITIN-10.

When it comes to the sub-sample analysis[35], the results are truly inspiring once again. After adjusting for the transaction costs there is only one case, when the analyzed benchmark is beaten by the active strategy during the first sub-sample, and only two cases in the second sub-sample. What is really important is that all the profitable strategies exceed the benchmark only marginally. Also it is worth adding, that the LITIN-10 should also be exposed to the same bid/ask premium in the real word. In order to eliminate the existing profit opportunities within the samples only 0.02% for the bid/ask premium is enough and it is hard to imagine that even such a small the bid/ask spread could exist. Therefore it can be surely concluded, that the performed moving average analysis without any arbitrary assumptions proves the randomness within the changes of the LITIN-10 and its weak-form efficiency in the analyzed sub-periods.

When comparing buying and shorting strategies, it becomes apparent that in the case of the LITIN-10 the buying strategy is a much better solution. As can be seen from the table, the long-cash strategy yielded higher return when the whole sample was considered, as well as higher return in most cases when sub-samples were analyzed.

Finally, one can observe from appliance of the MA strategies that the LITIN-10 is indeed the best representative of the most liquid part of the Lithuanian Stock Market. Such a conclusion comes from the fact that the analyzed MA strategies triggered all in all 182 buy/sell signals and this number is really higher than in the case of the LITIN-G (136 signals) and in the case of the LITIN (139 signals). In addition, it can be said that due to such a high number of signals, the MA strategies for the LITIN-10 probably caught most of the trends and could not make any profits from them no matter what length of the MA was used. This once again suggests that the most liquid stocks of the Lithuanian Stock Market are the weak-form efficient.

In the final part of this section some words should be said about the LITIN index the results of which are summarized in the ninth table.

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[35] The data/tables associated with results for sub-sample analysis can be found in the fifth appendix.

Table 9 *Returns of the Different MA Strategies for the LITIN Index*

Portfolio type	MA 10	MA 50	MA 100	MA 200
Long-cash	161.62%	118.71%	102.76%	95.35%
Long short	440.30%	254.11%	164.56%	102.77%
Long- cash*	87.72%	96.94%	95.80%	91.97%
Long-short*	179.48%	186.25%	145.88%	95.14%
Long-cash**	-26.82%	**46.27%**	**77.31%**	**82.68%**
Long-short**	9.31%	**110.71%**	**120.54%**	**83.90%**
B&H	31.75%	31.75%	31.75%	31.75%

Source: data from the NSEL and the author's calculations

*denotes portfolios adjusted for the transaction costs;
**denotes portfolios adjusted for the transaction costs and the bid/ask premium

As can be noticed from the table, the MA strategies would be profitable for the LITIN if there were no transaction costs. However, an introduction of them still does not eliminate profitability associated with the trading strategies based on the moving averages. In addition, even the 1% bid/ask premium is helpless in elimination process of profitability - 6 out of 8 strategies do generate higher returns than the given benchmark. Therefore the most apparent conclusion is that the randomness, as well as the weak-form efficiency, is not common for the LITIN index.

The good news is that the profitability of strategies based on the moving averages fades with time. This can be most obviously noticed from the sub-sample analysis[36]. As can be seen, the first sub-sample perfectly replicates the overall sample. More specifically, before the bid/ask adjustment all the strategies in the whole sample and in the first sub-sample yielded higher returns while after the bid/ask adjustment 7 out of 8 still remained profitable in both of them. This is not the case during the second sub-sample where only two profitable strategies were found for the transaction-cost-adjusted case, and none were found for the bid/ask-adjusted case. Such a finding strongly suggests that the MA based strategies are no longer profitable and therefore the LITIN seems to become more unpredictable than before.

In order to get a deeper picture of what is happening with the profitability and why certain results are obtained, some more thoughts can be expressed. Firstly, one can easily notice that during the first sub-sample the long-short strategy proved to be much more profitable than the long-cash strategy. This is a distinguishing feature if to compare with the results for other indexes. Of course, in the case of the LITIN-G the long-short strategy did outperform the long-cash strategies in some cases but not with

[36]The data/tables associated with results for sub-sample analysis can be found in the fifth appendix.

such consistency. In addition, seeing the long-cash portfolio regaining its positions during the second sub-sample might indicate that the final results do have some bias coming from the first sub-period. One possible explanation for such dramatic profitability of the long-short portfolio might be the fact that the LITIN index was falling during the first sub-sample. Since shorting opportunities, as mentioned in the paper before, are rather limited in Lithuania, produced returns during the first period highly influenced the total returns from actively managed the long-short portfolio. And since the second sub-sample analysis was performed while ignoring any returns from the previous period, such a "first sub-sample" bias can be explained to some extent. However, this explanation fails to give the answer why the long-cash portfolio also highly outperformed the B&H strategy during the first sub-sample and leaves this question opened for the further studies.

So in the end it can be concluded that the LITIN-G and the LITIN-10 seem to follow random walk and for the LITIN the hypothesis of the random walk has to be rejected.

6.2.2. Filter Rule Tests

Another way to seek some profits from the mechanical trading is to use different filters with a hope of catching trends. If these trends were identifiable and sustainable through the time, technicians using filters should be able to capitalize on them. If it is the case in Lithuania, one can see from the following tables in this section with the LITIN-G starting the research of the filter testing.

Table 10 *Returns Generated by the Different Filters for the LITIN-G Index*

Portfolio type	1%	2%	3%	4%
Long-cash	166.17%	182.54%	150.14%	92.318%
Long short	254.12%	306.92%	219.86%	95.672%
Long- cash*	89.66%	150.02%	136.54%	81.827%
Long-short*	80.01%	218.77%	186.08%	76.244%
Long-cash**	17.11%	25.32%	59.56%	25.703%
Long-short**	11.34%	35.12%	102.80%	21.996%
B&H	102.80%	102.80%	102.80%	102.80%

Source: data from the NSEL and the author's calculations

*denotes portfolios adjusted for the transaction costs;
**denotes portfolios adjusted for the transaction costs and the bid/ask premium

As can be seen from the table, the filter rules seem to work quite good for the LITIN-G. If no transactions cost were included, most of the strategies – namely six -

would exceed the B&H benchmark. The excessive returns diminish to some extent when the transaction costs are included – 4 out of 8 strategies still remain profitable. And only inclusion of the bid/ask premium helps to eliminate all the profitable strategies based on different filters. Therefore if the bid/ask premium is assumed to be determined in the right way, the LITIN-G index can be concluded to follow the random walk during the whole sample and therefore imply the weak-form efficiency for the whole Lithuanian Stock Market.

When it comes to the sub-sample analysis, the results are quite different during the different periods. It is easy to notice from the given table in appendix 5 that the inclusion of the trading costs does not reduce the number of profitable cost-free trading strategies during the first sub-sample. Even more important it is that despite the introduction of the bid/ask premium, 5 out of 8 strategies still remain profitable and such a result casts strong doubts about the weak-form market efficiency during the 2001-2002 period. The second sub-sample demonstrates an extraordinary unprofitability with the usage of filter rules. None of the strategies do outperform the B&H benchmark when trading expenses are considered. Even more important that none of the strategies would be profitable if the assumption of the bid/ask premium would be eliminated. What is mostly striking is the fact that only two strategies without any trading costs would beat the B&H benchmark and this is truly unexpected result for this index, especially when findings during the first sub-sample are recalled. Therefore it can be safely concluded that the overall unprofitability of the LITIN-G during the whole sample can be attributed to the second period when the LITIN-G index demonstrates the strongest efficiency observed so far by the technical trading rules.

Another filter testing object was the LITIN-10 index. The findings for this index are summarized in the 11th table.

Table 11 *Returns Generated by the Different Filters for the LITIN-10 Index*

Portfolio type	1%	2%	3%	4%
Long-cash	113.85%	109.75%	103.46%	59.40%
Long short	101.43%	95.09%	83.34%	19.42%
Long- cash*	42.10%	74.90%	83.21%	48.64%
Long-short*	-11.56%	35.74%	48.73%	3.87%
B&H	135.65%	135.65%	135.65%	135.65%

Source: data from the NSEL and the author's calculations

*denotes portfolios adjusted for transaction costs;

It can be seen from the table that the LITIN-10 does not provide with the profit opportunities while using the filter rule and therefore can be said to be the weak-form efficient index. This finding can be strengthened substantially by noting that even without adjustment for the trading costs (not taking about the bid/ask premium or even the bid/ask spread adjustment) none of the strategies outperforms the B&H benchmark. In other words, it can be safely concluded, that the LITIN-10 is the weak-form efficient in its strictest form which is not required to hold in practice.[37]

Also it is important to note that when the case of the LITIN-10 is considered and when the filter rule is applied, it appears that the long-cash strategy is superior in all cases and therefore at least when it comes to making conclusions about the most liquid stocks within the Lithuanian Stock Market, an absence of the selling short option is not a major drawback.

The sub-sample analysis[38] does not reveal any noticeable evolution of the profitability. In fact, none of the strategies even without introducing the trading costs can pose any threat to the B&H portfolio and therefore the LITIN-10 seems to be the efficient as well as during the sub-samples, as the during whole sample.

This section is finalized with the LITIN analysis, and the main results for the following discussion can be found in 12th table.

Table 12 *Returns Generated by the Different Filters for the LITIN Index*

Portfolio type	**1%**	**2%**	**3%**	**4%**
Long-cash	130.07%	107.07%	83.73%	77.45%
Long short	301.75%	233.29%	157.47%	150.06%
Long- cash*	43.55%	-0.35%	61.45%	64.10%
Long-short*	56.67%	97.52%	98.90%	111.51%
Long-cash**	-61.99%	-24.26%	11.86%	**51.30%**
Long-short**	-58.73%	-5.87%	**37.99%**	**66.86%**
B&H	31.75%	31.75%	31.75%	31.75%

Source: data from the NSEL and the author's calculations

*denotes portfolios adjusted for the transaction costs;
**denotes portfolios adjusted for the transaction costs and the bid/ask premium

Before any transaction costs are introduced, the filter rule appears to be highly

[37] As noted in the methodological part, the section *Definition of Testable Market Efficiency and Hypothesis Formulation* "the prices reflect information to the point where the marginal benefits of acting on information (the profits to be made) do not exceed the marginal costs." (as quoted by Fama, 1991). However, in the case of the LITIN-10 seems that even with marginal costs equal to zero no profits can be realized and therefore this index is compatible with the strictest form of the weak-form market efficiency.

[38] The data/tables for which can be found in the fifth appendix.

profitable in the case of the LITIN – all strategies do exceed the B&H benchmark. However, when just a simple adjustment for trading costs occurs, the situation does change marginally - 7 out of 8 strategies remain profitable when compared with the B&H portfolio. Only after the 1% bid/ask premium is introduced, 5 out of 8 strategies lose their profitability. Nevertheless, the fact that three strategies still generate abnormal returns for the LITIN, gives the strong background to reject the weak-form efficiency for the LITIN during the whole sample.

In essence, the sub-sample analysis reveals the results for the whole sample[39]. After looking at returns during the different periods it becomes clear that essentially the first sub-sample contributes to the overall profitability of the filter-rule based strategies. Once again, before the introduction of the bid/ask premium of 1% for the LITIN, all only transaction-cost adjusted strategies are profitable in the first sub-sample. After adjusting for the bid/ask premium, five strategies still exceed the B&H benchmark. Even more important it is to note, that three excessive returns generating strategies during the first sub-sample are the ones, which generate profit during the whole sample. It is not less important to draw one's attention to the fact that during the second sub-sample only one strategy can remain profitable when trading costs are introduced and none remain profitable after the bid/ask premium takes place. All facts stated above clearly indicate that profitability drops during the second sub-sample and therefore, according to this research, it can be stated that either market starts more intensively to use technical analysis - namely the filter rules - and in that way declines any possible profits from this strategy or the LITIN approaches the weak-form efficiency. However, one thing is for sure - under the current circumstances the random walk hypothesis for the LITIN index is rejected.

In the ending lines of this section it can be summarized that the LITIN-G and the LITIN-10 indexes appear to be unprofitable with the filter-rule based strategies and therefore the weak-form efficient, while the filter-rule based strategies seem to generate abnormal returns for the LITIN and therefore the hypothesis of the weak-form efficiency for this index is rejected.

[39] The data/tables associated with results for sub-sample analysis can be found in the fifth appendix.

7. Discussion of the Results

In this section the discussion of the results is presented. The section starts with discussing the results for the statistical tests and ends up with the discussion of the results for the technical trading rules. Such a sequence is not coincidental. The author believes that the statistical tests reveal predictability within the changes in three different indexes. However, the existence of predictability does not necessary mean that the found "predictability factor" could be exploited profitability. Therefore finalized conclusions about the weak-form market efficiency can be done after discussing the technical trading rules. It also worth mentioning that the results for the different indexes are discussed separately in order to familiarize the reader with the weak-form efficiency within the different segments of the Lithuanian Stock Market.

7.1. Discussion of the Results of the Statistical Tests

Despite the fact that statistical analysis concentrates more on analyzing the distributional patterns, its conclusions are also very valuable. This is mainly because statistical analysis is the first tool, which reveals even theoretical possibilities of profitable trading and indicates whether any need of inventing technical trading rules – no matter how much sophisticated – is rational. Without statistical analysis, the tests of technical trading rules would lose its scientific background.

First of all, the discussion of the results will be done with the LITIN-G index. The conclusions from the statistical tests can be found in the 13th table.

Table 13 *The Main Characteristics Associated with Randomness of the LITIN-G*

Test name	**LITIN-G**		
	The whole sample	**The first sub-sample**	**The second sub-sample**
Autocorrelation test	Non-random/Predictable	Non-random/Predictable	Non-random/Predictable
Runs test	Non-random/Predictable	Random/Efficient	Non-random/Predictable
Distribution test	Random/Efficient	Non-random/Predictable	Random/Efficient

Source: The author's conclusions

After performing the first test – the autocorrelation test – the LITIN-G index was not found to follow the random walk during the whole sample as well as during the two sub-samples. After analyzing the individual sub-samples with autocorrelation coefficients it was found that in the second sub-sample there were more significantly different from zero autocorrelation coefficients (four as compared with two during the first sub-sample) and therefore it was concluded that the LITIN-G loses its randomness during the recent years. However, this conclusion was rather tentative since the Q test rejected the null hypothesis of the random walk for all the samples analyzed and for that reason there was no indication to which direction – increasing efficiency or inefficiency- the whole Lithuanian Stock Market had been heading.

The raised question above and preliminary conclusions were justified by the runs test. This test clear indicated the LITIN-G not being efficient during the whole period and in that way being consistent with earlier findings of the autocorrelation test. Even more important is to note that this test demonstrated that, in essence, the LITIN-G index lost its randomness during the second sub-sample and attributed this to increased positive autocorrelation. This test also showed that the first sub-sample is responsible for the overall non-randomness found within the LITIN-G.

Different results for the autocorrelation and runs test should not be treated as a drawback. As mentioned in the methodological section, the runs test is not so influenced by outliers and therefore might end up with more conclusive results. Therefore it might be noted that probably the JB test, which reported the second sub-sample as not being random, might have suffered from some outliers.

Finally very interesting results come from the normality testing. It is rather unexpected to see this test giving the opposite conclusion about the weak-form efficiency of the LITIN-G during the whole sample. In addition, the results for the second sub-sample are also controversial. However, after recalling the fact that skewness did not differ significantly from zero in all samples, and that the kurtosis parameter differed from 3 significantly in all cases, one might attributed the reported results to the methodological properties of the Q test and therefore remain rather reserved about the reported conclusions.

After stating all the arguments, it seems safe to concluded that statistical analysis gives stronger support to the fact that predictable patterns do exist within the LITIN-G during the whole period and also advocates that the predictive factor has gained more grounds during the second sub-period. In other words, the random walk hypothesis should be rejected for the whole period, as well as for the second sub-sample when the LITIN-G is considered.

The second index to be discussed is the LITIN-10. The main aspects of it revealed by the statistical analysis and associated with the weak-form efficiency are reported in 14^{th} table.

Table 14 The Main Characteristics Associated with Randomness of the LITIN-10

Test name	**LITIN-10**		
	The whole sample	**The first sub-sample**	**The second sub-sample**
Autocorrelation test	Random/Efficient	Random/Efficient	Non-random/Predictable
Runs test	Random/Efficient	Random/Efficient	Non-random/Predictable
Distribution test	Non-random/Predictable	Non-random/Predictable	Non-random/Predictable

Source: The author's conclusions

The test of autocorrelation clearly indicates that the LITIN-10 index is hardly predictable with the past data during the whole sample. Also it is important to note, that one might find only one (the first lag) autocorrelation coefficient significantly differing from zero in the first sub-sample. However, three significantly different from zero autocorrelation coefficients found in the second sub-sample indicate that the demonstrated weak-form efficiency might not be sustainable and that the LITIN-10 might be receding from the weak-form of market efficiency. These just expressed considerations are justified by the Q test the results of which are presented in the table above under heading "autocorrelation test".

The non-parametric test for autocorrelation – the runs test – reveals exactly the same results for the LITIN-10 as the parametric autocorrelation test. As can be seen from the table above, the runs test indicates that the LITIN-10 does follow the random walk during the whole period and therefore can be said to be the weak-form efficient. However, one might also notice that the findings from the runs test also indicate an increased level of predictability of the LITIN-10 during the second sub-sample. In fact, the null hypothesis of the random walk during the second sub-sample was rejected due to increased positive autocorrelation. However, it seems that the non-randomness of the second sub-sample is not so influential that could affect the results for the whole period.

Finally, some thoughts should be expressed about the normality test. As in the case of the LITIN-G, the results tend to deny the findings of earlier tests when the whole sample is considered. The good news, however, is that the normality test does agree with the arose non-randomness during the second sub-sample. The bad news is that is hard to give any valid explanation why the other results differ from previous ones.

In summary, it can stated with some arbitrary background[40] that the LITIN-10

[40] The arbitrary background comes from the fact that the results of the normality are ignored to some extent when final conclusions about the randomness and efficiency of the LITIN-10 are made.

appears to follow the random walk and therefore is the weak-form efficient during the analyzed period. The sub-sample analysis reveals that the weak-form efficiency might be threaten by decreased randomness coming from increased positive autocorrelation during the second sub-sample.

Before finishing this section, the results of statistical analysis for the LITIN index should be discussed. The summary of these results can be found in the 15th table[41].

Table 15 *The Main Characteristics Associated with Randomness of the LITIN*

Test name	**LITIN**		
	The whole sample	**The first sub-sample**	**The second sub-sample**
Autocorrelation test	Non-random/Predictable	Random/Efficient	Random/Efficient
Runs test	Non-random/Predictable	Random/Efficient	Non-random/Predictable
Distribution test	Non-random/Predictable	Random/Efficient	Non-random/Predictable

Source: The author's conclusions

As can be seen from the table, the common autocorrelation test reports quite conflicting results. While the whole sample is concluded not to follow the random walk, the randomness of changes in the LITIN is common during the both sub-samples. Certainly in such a situation is rather hard to give any valid explanation why the whole sample does not follow the random walk and therefore this strange finding can be attributed to the possible shortcomings of the test employed.

It is necessary to point out that the problem of inconclusiveness of the previous test is successfully solved with the non-parametric autocorrelation test. As well as the ordinary autocorrelation test, the runs test reveals the non-randomness of the LITIN during the whole sample. But it is much more important, that this test detects the non-randomness of the LITIN during the second sub-sample and in that way gives a plausible explanation why the LITIN index is not following the random walk during the whole period. Namely, this test tries to evidence the fact the period of 2003-2004 is responsible for the rejection of the null hypothesis of the random walk for the whole period. In addition, as one might recall from the normality test for the LITIN, there were two outliers in the original data sample of the LITIN and therefore

[41] It is necessary to mention that the results of the normality test are taken from the adjusted for two outliers data set. As discussed in the section of results, parameters from adjusted sample should reveal a more objective picture of distribution of the LITIN index.

the non-parametric test in such a situation has greater power to give more objective results.[42]

It is also important to state, that the normality test for the first time demonstrates consistency with earlier results. Therefore no further comments about this test will be made here.

In ending lines of the weak-form efficiency analysis of this index it can be stated that the LITIN does not follow the random walk during the whole period and therefore the weak-form market efficiency hypothesis cannot be accepted. It is also important to stress that the non-randomness of the LITIN increases during the second sub-sample and this increase can be attributed to the found overall non-randomness of this index.

7.2. Discussion of the Results of the Technical Trading Rules

As one might recall from the section *Definition of Testable Market Efficiency and Hypothesis Formulation* the null hypothesis was formulated in the following way:

The Lithuanian Stock Market follows the random walk/is the weak-form efficient.

However, the rejection of the null hypothesis, as also discussed in that section, means only that the Lithuanian Stock Market does not follow the random walk and not necessary means that the market is not the weak-form efficient. In other words, the rejection of the null hypothesis fails to give the final answer about the weak-form market efficiency mainly because statistical tests only indicate that returns are predictable to some extent. However, statistical tests do not answer the question whether this predictability is high enough to generate profits over the market portfolio. Therefore it might be possible to say that if technical rules are found to be profitable, then the rejection of the null hypothesis can also mean that the Stock Market is not the weak-form efficient. However, if the technical rules fail to beat the market portfolio, the randomness of the indexes can be rejected with statistical analysis but the Stock Market cannot be concluded to be the weak-form inefficient. According to this logic the following discussion of the results of the technical trading

[42] The original sample was adjusted only for the normality test. This was done in order to demonstrate that the distributional pattern of the LITIN index does not differ dramatically, as firstly indicated by the normality test, from the other two indexes. In addition, the author of this paper does understand the consequences of adjustments to the statistical analysis, and therefore such manipulation with data was implemented only once for the purpose stated above.

rules will be organized and the final conclusions about the Lithuanian Stock Market efficiency will be made.

The first thoughts will be expressed about the LITIN-G. As it has already been mentioned many times before, this index represents the whole Lithuanian Stock Market and therefore the conclusions from its analysis are very important.

Table 16 *The Main Characteristics Associated with Efficiency of the LITIN-G*

Test name	**LITIN-G**		
	The whole sample	**The first sub-sample**	**The second sub-sample**
Moving average rule	Unprofit./Efficient	Profitable/Inefficient	Unprofit./Efficient
Filter rule	Unprofit./Efficient	Profitable/Inefficient	Unprofit./Efficient

Source: The author's conclusions

As can be from the table both mechanical rules yielded the same results and therefore will be discussed at the same time. It should be clear that the LITIN-G index, as well as the whole Lithuanian Stock Market, appears to be the weak-form efficient during the whole sample. However, such efficiency is only obtained when the bid/ask premium is included. Therefore this conclusion is rather arbitrary and rests on the assumption that the bid/ask premium is indeed not smaller than 2.5% per trade. Of course, this assumption might be a very good approximation of the real world, but on the other hand, it is hardly expectable that any of investors with the current state of liquidity in the Lithuanian Stock Market would try to replicate the LITIN-G index. Therefore only theoretically it can be concluded that the LITIN-G index should be the weak-form efficient.

In addition, it is worth mentioning that conflicting results from statistical analysis concluding the Lithuanian Stock Market not to be random and results from the technical analysis stating that the Lithuanian Stock Market is efficient clearly lead back to the discussion at the beginning of this section. Despite the fact that statistical analysis rejects the randomness hypothesis, it does not reject the weak-form market efficiency. And since existing non-randomness does not yield any abnormal returns with the technical strategies analyzed, the Lithuanian Stock Market can still remain the weak-form efficient during the whole period.

Since some doubts about the practical aspects of the LITIN-G analysis were expressed, the author feels a need to discuss the situation without the inclusion of the bid/ask premium. In fact, the results would differ when the whole sample would be considered but would remain the same when the evolution of the profitability would be analyzed. More specifically, the analysis without the bid/ask premium concludes that the LITIN-G is not profitable during the whole period and therefore is not the weak-form efficient[43]. After performing the sub-sample analysis with the bid/ask premium inclusion, the decreasing profitability was also detected – the second sub-sample did not provide with any profits no matter which technical trading strategy would had been used. In addition, it is worth mentioning that the overall inefficiency revealed with the analysis without the bid/ask spread is consistent with the findings of the statistical analysis and therefore once again casts some doubts on the bid/ask premium, namely - its size.

Still one fact still remains very surprising – namely, the arising conflict between the statistical and technical analysis when the first sub-sample is analyzed. It is strange to find that while being random according to the statistical analysis, the index is also very profitable. Currently is hard to explain such a finding. One of the solutions might be to attribute this finding to the problem of data mining[44]; other, attribute it to the fact that both the MA strategies and the filter rules have detected the non-linear patterns which could not be found with the used statistical analysis tools in this paper. However, in order to be accurate, some more research should be conducted.

In conclusion, if the bid/ask premium is assumed to be rightly determined, the Lithuanian Stock Market is the weak-form efficient during the whole sample. However, if one makes conclusions without the bid/ask premium, the LITIN-G is not found to be the weak-form efficient as well as the whole Lithuanian Stock Market. The sub-sample analysis with and without the bid/ask premium conclude the same – namely, the profitability decreases during the past years and therefore detected non-randomness by the statistical analysis during the second sub-sample does not threaten the weak-form of market efficiency in Lithuania.

The results for the LITIN-10 index, representing the most liquid part of the Lithuanian Stock market are summarized in the 17th table below.

[43] Here it can be said that the rejection of the randomness leads to the rejection of the weak-form market efficiency, since abnormal returns are generated by the technical trading rules.
[44] As noted by Neely, a certain strategy might be profitable for a certain data set by chance and therefore not sustainable in longer periods (1997). However, such a suggestion should be tested in other researches in order to get the final conclusions.

Table 17 *The Main Characteristics Associated with Efficiency of the LITIN-10*

Test name	**LITIN-10**		
	The whole sample	**The first sub-sample**	**The second sub-sample**
Moving average rule	Unprofit./Efficient	Unprofit./Efficient	Unprofit./Efficient
Filter rule	Unprofit./Efficient	Unprofit./Efficient	Unprofit./Efficient

Source: The author's conclusions

It can be noticed once again that the results for the different trading rules are exactly the same. The only difference, which might be found after deeper analysis, is that the moving average strategy does require 0.02% bid/ask premium to make the LITIN-10 unprofitable during the two sub-samples. However, in author's opinion this 0.02% bid/ask premium should not be treated as an assumption but as inevitable costs in the real investment environment. In the case of the filter rule, none of the filters generate higher return when the one provided by the B&H portfolio even when no transaction costs are considered. Such a finding gives support to the strongest form of the weak-market efficiency and surely concludes that the most actively traded companies in Lithuania do follow the random walk.

When the results from technical rules are compared with the results from the statistical analysis only one inconsistency is found. More specifically, the statistical analysis indicates the non-randomness of the LITIN-10 during the second sub-sample. As proved by the tests of the mechanical trading rules this non-randomness cannot be exploited profitably and therefore the hypothesis of the weak-form market efficiency should hold during the second sub-sample.

In conclusion, the LITIN-10 index appears to be the weak-form efficient. Such a conclusion comes from the fact that the LITIN-10 was found to be the weak-form efficient as well as during the whole sample, as during the analyzed sub-samples. Therefore it can be safely stated that at least the most liquid part of the Lithuanian Stock Market is, without any arbitrary assumptions, the weak-form efficient part of the market and these 10 securities do reflect the new information instantly and without any predictable pattern.

This section is finalized with the discussion of the LITIN index and the results from the appliance of the technical trading rules are summarized in the 18th table.

Table 18 *The Main Characteristics Associated with Efficiency of the LITIN*

Test name	**LITIN**		
	The whole sample	**The first sub-sample**	**The second sub-sample**
Moving average rule	Profitable/Inefficient	Profitable/Inefficient	Unprofit./Efficient
Filter rule	Profitable/Inefficient	Profitable/Inefficient	Unprofit./Efficient

Source: The author's conclusions

From the first sight at the given table, one might conclude that the LITIN does not follow the random walk during the whole analyzed period. It is even more important to note that since both technical trading strategies were found to generate abnormal returns during the whole sample and since the statistical analysis rejected the null hypothesis of the random walk, the LITIN index can be concluded not only to be non-random, but also to violate the assumption of the weak-form market efficiency. However, one should remember that this conclusion is based on the 1% bid/ask premium. Nevertheless, it can be stated that unlike in the case of the LITIN-G, the LITIN index can be easily replicated[45] and it is hard to expect the bid/ask premium of such size not to be encountered by investors. In addition, as one might recall from the section of the results, the conclusion for the whole period does not change if the bid/ask premium is removed.

When it comes to sample analysis, the tentative picture is rather clear – profitability does decrease during the years implying that the LITIN index might be approaching the weak-form market efficiency. However, it is very hard to give the valid explanation for the conflicting results coming from the statistical analysis and the technical analysis during the first sub-sample. While the statistical test all as one indicate the LITIN index to be random during the first sub-sample, the two trading strategies report high excessive returns for the same period. Following the logics of the random walk, none of the technical trading strategies should be profitable under the presence of randomness. Therefore the author can only state that at the current stage only one thing is clear – the performed analysis in this paper is not enough to explain the found phenomenon and further researches in this sphere are necessary (perhaps the ones which go into the analysis of the non-linear patterns). However, since the same phenomenon was found in the LITIN-G index, one might attributed it

[45] The reason for this might be the number of companies comprising the two indexes. While the number of companies included in the LITIN-G varied about 45-50 during the analyzed period, one could find on average only 8 companies within the LITIN during the same period.

to the companies from the official list[46]. Therefore only when the paradox associated with the LITIN is clarified, one should start reanalyzing the LITIN-G.

The case of the second sub-sample is more straightforward – it seems that detected non-randomness by the statistical analysis is not enough to generate profits with the technical strategies analyzed. Therefore the weak-form efficiency of the LITIN during this period might be said to exist.

In conclusion, the LITIN index can be concluded to be both – non-random and the weak-form inefficient during the whole period. The only good news is that this index seems to approach the weak-form market efficiency despite the decreasing non-randomness.

[46] The vice versa way of attribution is not possible since the companies comprising the official list weight substantially more in the LITIN-G index than companies not included in the official list.

Conclusions

The aim of this paper was to prove or deny the hypothesis of the weak-form efficiency in the Lithuanian Stock Market. This was done while employing two different but one another complementing techniques – the statistical analysis and the technical trading rules. It was strongly believed that such a combination of testing could yield the best final conclusions. In addition, it is worth remembering that this paper concentrated not solely on the weak-form efficiency of the whole market, but also on separate parts of it described by the different indexes.

Following the structure of the conducted research the conclusions for the LITIN-G will be made at the beginning of this section. The final conclusion from the statistical analysis was that this index did not follow the random walk during the whole sample. In addition, the same analysis revealed that the detected non-randomness during the second sub-sample was most probably responsible for the overall non-randomness within the index, and therefore the LITIN-G was concluded to lose its randomness during the last years.

However, the results for the technical analysis indicate that the final conclusion, in essence, lies on the veracity of the bid/ask assumption. If one assumes that the bid/ask premium of 2.5% is rightly determined[47], then the detected non-randomness is not enough to generate excessive returns with the analyzed technical trading rules and therefore, despite being non-random, the LITIN-G should be accepted as being the weak-form efficient for the whole period. On the other hand, if one would reject the assumption of the bid/ask premium, the LITIN-G would be the weak-form inefficient, since the technical trading rules would generate excessive returns. Nevertheless, one should not forget the fact that the replication of the LITIN-G would be hard to expect in Lithuania, and therefore one should accept the bid/ask premium as a methodological tool, which is necessary to obtain finalized conclusions. Following this, the final conclusion is that the LITIN-G, with some arbitrary background, is found to be the weak-form efficient during 2001-2004.

[47] No matter how many calculations would be done, the size of the bid/ask premium would remain an assumption. This is mainly because it is practically impossible to predict how much he prices of certain securities would change if the demand of or supply for them would change dramatically. In other words, the bid/ask premium cannot be observed and therefore must be assumed (for more extensive discussion, see the sixth appendix).

The sub-sample analysis with and without the bid/ask premium conclude the same – namely, the profitability decreases during the past years and therefore detected non-randomness by the statistical analysis during the second sub-sample does not threaten achieved the weak-form of market efficiency in Lithuania.

The statistical analysis of the LITIN-10 index revealed that this index did follow the random walk during the whole period. However, the same analysis revealed that the LITIN-10 has lost some of the earlier randomness during the last years and therefore appears to be non-random during the second sub-sample. Nevertheless, the technical analysis clearly indicated that there were no profit opportunities either throughout the whole sample, or during the sub-samples. For that reason it is safe to conclude that the increased non-randomness does not threaten the weak-form market efficiency so far, but may be a start of a bad tendency. However, at the current point it is clear that the LITIN-10, as well as the most liquid part of the Lithuanian Stock Market, is the weak-form efficient.

Finally, the statistical research of the LITIN index strongly suggests that this index was not random during the whole analyzed period. In addition the same analysis attributed the detected non-randomness during the whole period to the increased predictability of this index during the second sub-sample. The technical analysis provided with the same results for the whole sample and therefore the LITIN can be surely concluded to be non-random and the weak-form inefficient during the whole period. In other words, it appears that when all the companies from the official list are taken at the same time, they are not consistent with the weak-form of the market efficiency. Certainly this does not imply that separately taken companies cannot demonstrate the weak-form efficiency.

The sub-sample analysis for the LITIN did not provide with many insights. In fact, the conflict between the results from the statistical analysis and the technical analysis during the first period suggests that further research in this field is necessary. However, the fact that the detected non-randomness during the second period cannot be exploited with technical strategies generating excessive profits during the first sub-sample leads to a conclusion the weak-form market efficiency measured by this index seems to improve during the last years.

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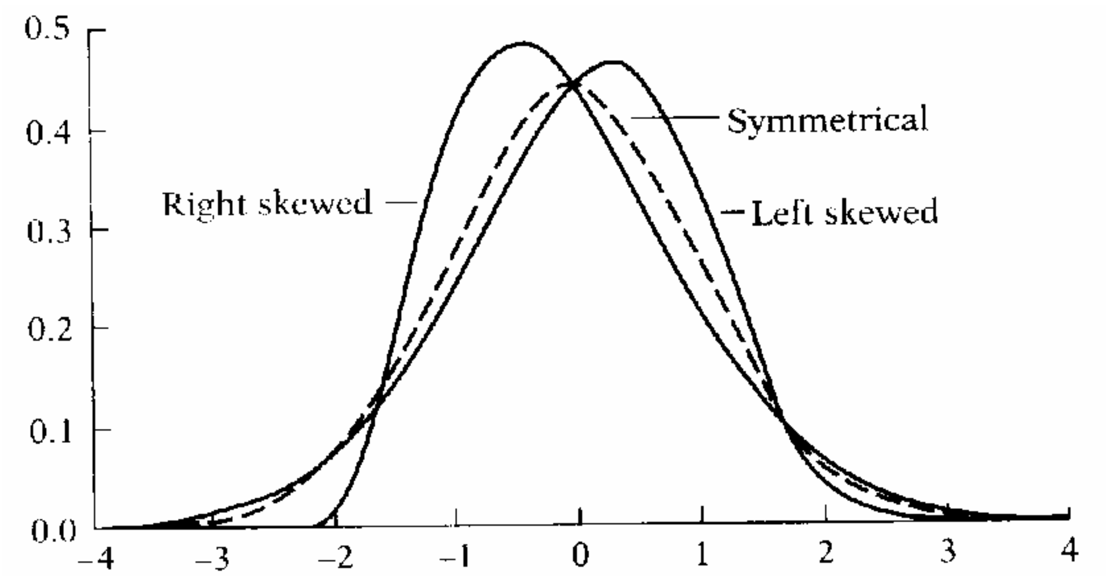
Appendices

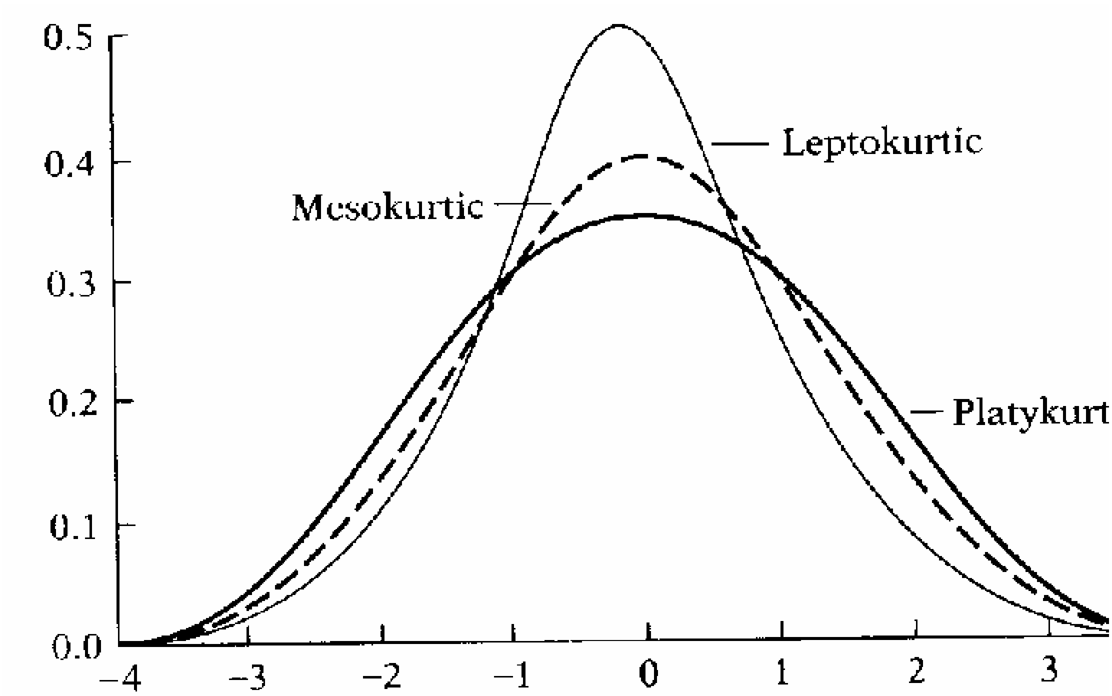
This section of the dissertation presents more in depth presentation of some concepts and data used in the body of the dissertation.

Appendix 1: Skewness and Kurtosis, and Their Graphical Patterns

Graph 4 *Forms of Symmetry and Skewed Distributions*



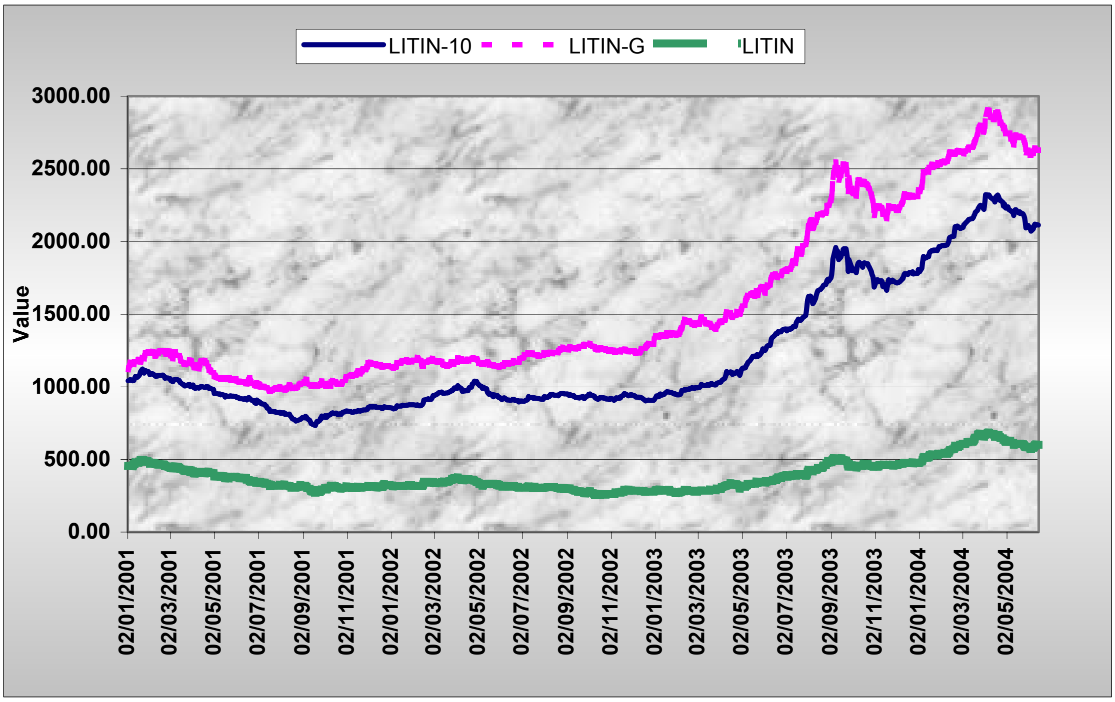
Graph 5 *Forms of Mesokurticness*



Appendix 2: Graphical Dynamics and Descriptive Statistics for the Different Indexes during the Different Periods

This appendix contains a graph showing dynamics of different indexes as well as presents a table showing growth rates for the different periods.

Graph 6 *Dynamics of the Different Indexes during January, 2001 – June, 2004*



Source: data from the NSEL and the author's calculations

Table 19 *Growth of the Different Indexes during the Different Periods*

Index	The whole sample (2001/01/02-2004/06/14	The 1st sub-sample (2001/01/02-2002/09/20)	The 2nd sub-sample (2002/09/23-2004/06/14)
LITIN-G	102.80%	-10.96%	126.39%
LITIN-10	135.65%	14.57%	105.34%
LITIN	31.75%	-38.91%	116.12%

Source: data from the NSEL and the author's calculations

Table 20 *Descriptive Statistics of the Different Indexes in Different Periods*

	LITIN-G	LITIN-10	LITIN	LITIN-G	LITIN-10	LITIN	LITIN-G	LITIN-10	LITIN
	The whole sample			The 1st sub-sample			The 2nd sub-sample		
Sample size	873	873	873	437	437	437	436	436	436
Mean	0.0008	0.0010	0.0003	-0.0003	0.0003	-0.0011	0.0019	0.0017	0.0018
Stand. deviation	0.0084	0.0091	0.0121	0.0076	0.0087	0.0119	0.0090	0.0095	0.0121
Kurtosis	2.84	2.09	3.86	1.62	1.39	3.41	3.38	2.57	4.71
Skewness	0.09	0.23	-0.35	0.06	0.16	-0.21	0.02	0.27	-0.52
Minimum	-0.0445	-0.03	-0.0738	-0.036	-0.0276	-0.0626	-0.0445	-0.0336	-0.0738
Maximum	0.0450	0.04	0.0585	0.0274	0.0299	0.0585	0.0450	0.0406	0.0459

Source: data from the NSEL and the author's calculations

Appendix 3: Formulas for Index Calculation and Additional Methodological Aspects of Index Computation

The capitalization-weighted equity indices - that is LITIN-G and LITIN - are calculated according to the following formula *(official NSEL website)*:

$$LITIN_t = 1000 \; x \; K_t \; x \; M_t/M_o$$

where:

M_0 – base capitalization of the issues on the index base (at the index inception);

M_t – total capitalization of the issues included in the index base at time t;

K_t – adjustment factor, which insures index continuity after any adjustments are made to the index composition.

Adjustments to the composition of LITIN and LITIN-G indices are made if:

1) The size of the share issue included into the index base increases or decreases (issue split, assimilation of issues);
2) Par value of shares changes;
3) Issues in the index base are changed following the decision of the NSEL Management Board (upon removal/admission of shares from/to the NSEL lists of listed securities).

The price index – the LITIN-10 – is calculated using the formula below:

$$LITIN\text{-}10_t = 1000 \; x \sum (P_{ti} x Q_{bi}) / \sum (P_{bi} x Q_{bi})$$

where:

$Q_{bi} = 1000/P_{bi}$ – number of shares of an issue (i) included into the index base;

P_{bi} – market price of a share at the index inception;

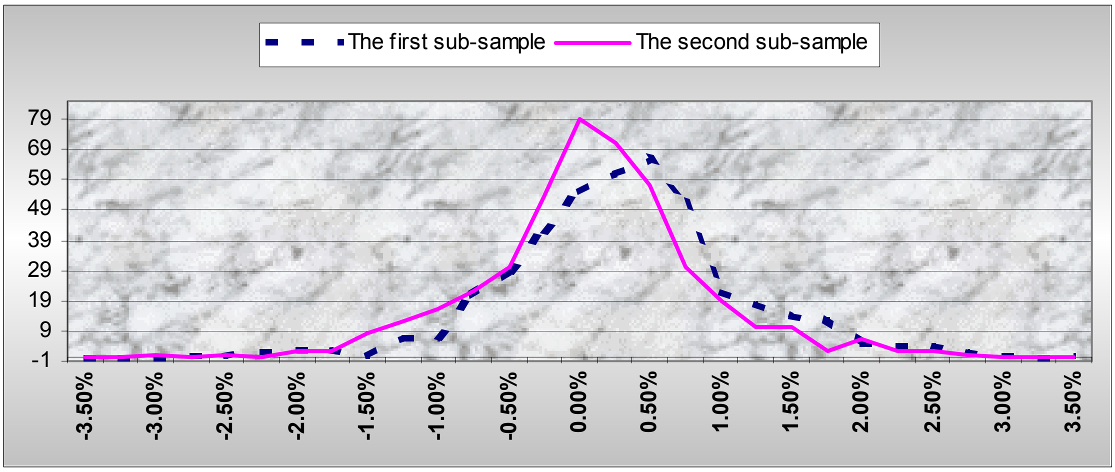
P_{ti} – market price of a share at a time *t*.

The value of $\sum P_{bi} x Q_{bi}$ in the index base is fixed and it always equals 10,000. Only the value of $\sum P_{ti} x Q_{bi}$ changes depending on the market price of shares and its proportion to the base determines the index value. For the calculation of the index, market share price (in Litas) is used.

The NSEL equity indices are expressed in points. Initially, all indices equaled 1,000 points. Closing market prices (in litas) of shares are used while calculating the indexes.

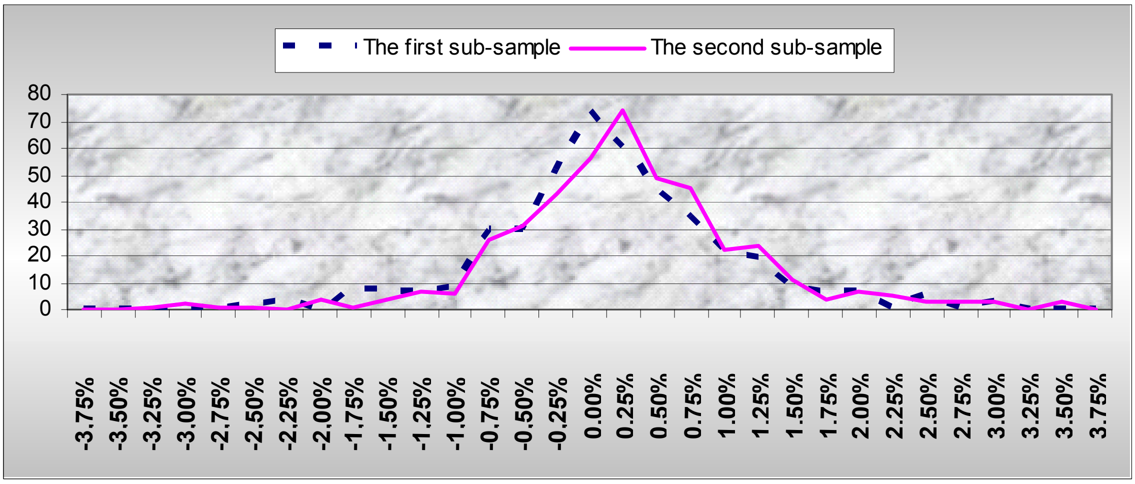
Appendix 4: The Graphical Comparison of the Different Indexes during the Different Sub-samples

Graph 7 *Distribution of Changes of the LITIN-G in the Analyzed Sub-samples*



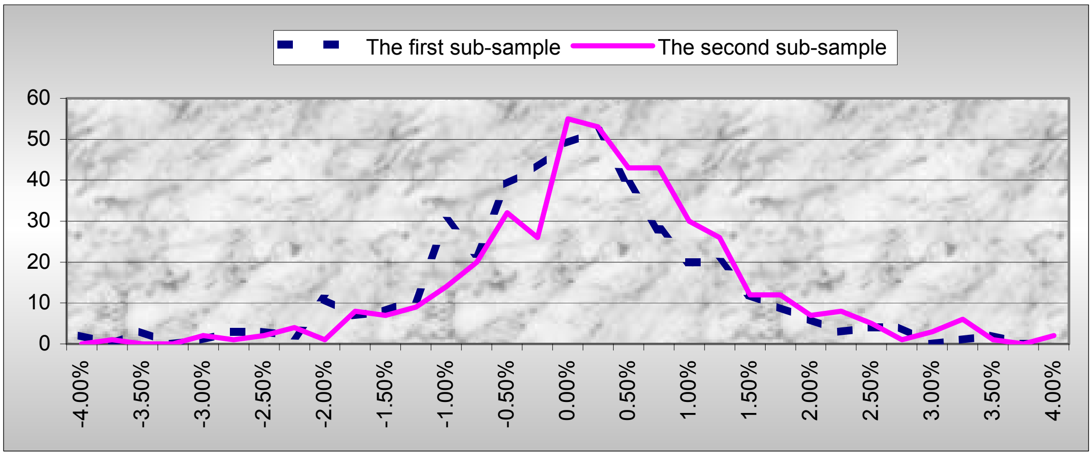
Source: data from the NSEL and the author's calculations

Graph 8 *Distribution of Changes of the LITIN-10 in the Analyzed Sub-samples*



Source: data from the NSEL and the author's calculations

Graph 9 *Distribution of Changes of the LITIN in the Analyzed Sub-samples*



Source: data from the NSEL and the author's calculations

Appendix 5: Returns of the Different Mechanical Strategies within the Sub-samples of the Different indexes

Table 21 *Returns of the Different MA Strategies for the LITIN-G within the Sub-samples*

	The first sub-sample				The second sub-sample			
Portfolio type	**MA 10**	**MA 50**	**MA 100**	**MA 200**	**MA 10**	**MA 50**	**MA 100**	**MA 200**
Long-cash	19.83%	19.60%	7.92%	5.69%	135.40%	135.44%	99.87%	48.69%
Long short	65.73%	60.39%	17.33%	-1.56%	147.27%	149.58%	88.01%	48.69%
Long- cash*	3.47%	17.12%	3.49%	4.59%	107.58%	131.36%	95.04%	48.69%
Long-short*	24.07%	53.28%	7.54%	-3.93%	92.36%	141.03%	79.05%	48.69%
Long-cash**	-62.27%	**1.05%**	-22.97%	**-2.85%**	-14.40%	104.58%	64.18%	48.69%
Long-short**	-54.60%	**32.31%**	-19.88%	-10.95%	-20.44%	113.21%	50.81%	48.69%
B&H	-10.96%	-10.96%	-10.96%	-10.96%	126.39%	126.39%	126.39%	126.39%

Source: data from the NSEL and the author's calculations

Table 22 *Returns of the Different MA Strategies for the LITIN-10 within the Sub-samples*

	The first sub-sample				The second sub-sample			
Portfolio type	**MA 10**	**MA 50**	**MA 100**	**MA 200**	**MA 10**	**MA 50**	**MA 100**	**MA 200**
Long-cash	-2.14%	12.48%	10.93%	17.58%	101.40%	116.48%	72.82%	41.31%
Long short	-11.36%	19.90%	0.49%	11.84%	98.18%	124.87%	67.45%	41.31%
Long- cash*	-24.70%	5.25%	4.53%	**16.35%**	70.90%	**111.99%**	69.83%	41.31%
Long-short*	-47.29%	5.38%	-11.06%	9.14%	42.79%	**115.66%**	61.71%	41.31%
B&H	14.57%	14.57%	14.57%	14.57%	105.68%	105.68%	105.68%	105.68%

Source: data from the NSEL and the author's calculations

Table 23 *Returns of the Different MA Strategies for the LITIN within the Sub-samples*

	The first sub-sample				The second sub-sample			
Portfolio type	**MA 10**	**MA 50**	**MA 100**	**MA 200**	**MA 10**	**MA 50**	**MA 100**	**MA 200**
Long-cash	3.22%	7.23%	5.62%	-3.18%	165.41%	94.11%	102.72%	52.22%
Long short	80.99%	80.70%	51.76%	5.66%	214.90%	83.26%	101.37%	52.22%
Long- cash*	-14.53%	2.83%	4.88%	-4.52%	133.22%	82.92%	102.02%	52.22%
Long-short*	24.62%	65.61%	49.13%	2.40%	143.27%	62.77%	99.97%	52.22%
Long-cash**	-49.96%	**-8.71%**	**2.82%**	**-8.23%**	61.60%	54.54%	83.12%	99.07%
Long-short**	**-26.76%**	**45.95%**	**45.08%**	**-2.33%**	68.77%	37.60%	72.47%	95.31%
B&H	-38.91%	-38.91%	-38.91%	-38.91%	116.12%	116.12%	116.12%	116.12%

Source: data from the NSEL and the author's calculations

Table 24 *Returns Generated by Different Filters for the LITIN-G within the Sub-samples*

	The first sub-sample				The second sub-sample			
Portfolio type	**1%**	**2%**	**3%**	**4%**	**1%**	**2%**	**3%**	**4%**
Long-cash	15.60%	25.95%	16.95%	-3.99%	132.45%	122.01%	111.69%	100.29%
Long short	51.88%	83.29%	57.98%	10.23%	140.15%	119.73%	100.38%	79.42%
Long- cash*	-3.60%	20.36%	14.12%	-5.99%	100.72%	105.59%	105.14%	93.42%
Long-short*	5.67%	67.40%	50.45%	6.45%	79.16%	88.47%	88.19%	67.33%
Long-cash**	-25.56%	**-6.87%**	**-3.93%**	-16.88%	62.91%	33.18%	64.38%	51.23%
Long-short**	-18.32%	**21.70%**	**26.72%**	**-5.83%**	45.51%	9.88%	50.92%	30.94%
B&H	-10.96%	-10.96%	-10.96%	-10.96%	126.39%	126.39%	126.39%	126.39%

Source: data from the NSEL and the author's calculations

Table 25 *Returns Generated by Different Filters for the LITIN-10 within the Sub-samples*

	The first sub-sample				The second sub-sample			
Portfolio type	**1%**	**2%**	**3%**	**4%**	**1%**	**2%**	**3%**	**4%**
Long-cash	3.63%	3.77%	0.80%	-11.51%	104.16%	99.97%	99.68%	80.13%
Long short	-2.96%	-2.41%	-8.03%	-25.00%	105.33%	97.77%	97.23%	60.97%
Long- cash*	-16.85%	-6.23%	-5.67%	-14.55%	69.06%	84.53%	92.16%	73.95%
Long-short*	-37.90%	-20.28%	-19.45%	-30.06%	40.90%	68.46%	82.66%	50.12%
B&H	14.57%	14.57%	14.57%	14.57%	105.34%	105.34%	105.34%	105.34%

Source: data from the NSEL and the author's calculations

Table 26 *Returns Generated by Different Filters for the LITIN within the Sub-samples*

	The first sub-sample				The second sub-sample			
Portfolio type	**1%**	**2%**	**3%**	**4%**	**1%**	**2%**	**3%**	**4%**
Long-cash	1.77%	-13.91%	1.61%	-14.34%	127.35%	140.52%	80.82%	107.15%
Long short	69.59%	23.87%	68.68%	24.43%	135.68%	164.67%	50.14%	97.68%
Long- cash*	-19.19%	-0.35%	-4.58%	-17.68%	79.90%	0.00%	69.79%	99.34%
Long-short*	7.02%	-7.59%	48.77%	13.64%	47.69%	110.25%	31.51%	83.08%
Long-cash**	-58.15%	-50.98%	**-20.18%**	**0.16%**	-7.42%	56.60%	42.04%	92.15%
Long-short**	-44.14%	**-38.85%**	**24.79%**	**0.16%**	-23.82%	51.74%	9.00%	64.22%
B&H	-38.91%	-38.91%	-38.91%	-38.91%	116.12%	116.12%	116.12%	116.12%

Source: data from the NSEL and the author's calculations

Appendix 6: The Bid/Ask Premium Concept and its Short Explanation

When defining the bid/ask premium, it is necessary to define a bid/ask spread. The bid/ask spread is a difference between a current bid, also known as a buying price, and a current ask, also called a selling price (Fabozzi & Modigliani, 1996, p. 113). Such a spread naturally exists in every single market and is influenced by many factors. One of the most important factors when considering the bid/ask spread is liquidity – the more liquid stock, the smaller is the bid/ask spread (vice versa is also true). The bid/ask spread also might be influenced by existence of market makers, who in essence create liquidity, and by the number of stocks available for public trading (ibid).

The bid/ask premium is a wider definition of the bid/ask spread. In this paper, the bid/ask premium takes into account the risk associated with a possible problem that existing demand of or supply for a certain security might be insufficient. In other words, if an investor wants, for example, to buy a certain amount of a certain security, he or she might be forced to bid the price of that security higher only because the supply at the first level of asking price is too low. The same is truth for a selling out of a certain security: if an investor wants to sell out a relatively high amount of a certain security, he or she may be forced to push the price of that security down further than the level of the highest bid. Such a risk is substantially higher when trading with illiquid stocks is taken into account or when larger portfolios are invested (for example, while replicating a certain index).

It is important to analyze the reasoning for choosing 2.5 percent bid/ask premium. The author of this paper admits that mentioned above number is more arbitrary one. More precisely, the 2.5 percent bid/ask premium was derived as a rough capitalization-weighted average adding some qualitative advices by professional brokers. There is no doubt that the bid/ask premium size itself is a very important variable in the efficient market analysis. However, the main reason of this paper was to show that even 2.5 percent bid/ask premium eliminates all the possibilities of profitable trading during the whole sample using technical systems and therefore is an essential benchmark for further studies in this field. In other words, if further studies discover the higher bid/ask premium that means that all the conclusions of this paper are valid. On the other hand, smaller than suggested in this paper bid/ask premium would result in possible revision of some of the conclusions made in this paper (namely, the ones associated with the LITIN-G index).

It is also important to note, that the bid/ask premium concept was also used in the analysis process of the LITIN index. The computing process of the bid/ask premium was the same as in the case of the LITIN-G. After some calculations and considerations the 1% bid/ask premium was found to be the most correct estimate.

Finally, it should be said that if one would try to replicate the LITIN-10 index, the bid/ask premium concerns would be also present. However, since the mechanical rules and the strategies based on them yielded in most cases lower return than the analyzed benchmark after adjusting for the trading costs, no real need was to determine the bid/ask premium for this index. It may be useful to state that in some cases in order to eliminate the excessive returns from investing in the LITIN-10, 0.02 % adjustment was necessary. Nevertheless, it is absolutely safe to conclude that this number is too small even for the bid/ask spread and not talking about the bid/ask premium.