MARKET EFFICIENCY OF CROATIAN STOCK MARKET

ABSTRACT

Capital market is considered to be efficient if prices fully reflect all available information. In this paper weak-form efficiency of Croatian capital market is tested. Tests have been implemented on five-year sample of CROBEX index returns and 6 stock returns. Econometric tests of autoregression, unit root test, Wald-Wolfowitz run test and examination of the possibility to model the returns with autoregressive models, have shown that the hypothesis on weak-form efficiency of Croatian capital market cannot be rejected, although there is not enough evidence in favor, too. Test results for chosen stocks follow the results for market index to a large degree. The final conclusion is that the Croatian capital market is weak-form efficient enough to prevent excess returns.

INTRODUCTION

The primary role of the capital market is efficient allocation of resources. The ideal market is the one in which market prices provide accurate signals for resource allocation, meaning the security prices fully reflect all available information and in that way enable firms to make production-investment decisions and investors to choose among the securities that represent ownership of firm's activities [1]. A market in which all relevant information is impounded into the prices of financial assets is considered to be efficient [2] and it is "unbeatable".

The logic standing behind the market efficiency is that if market prices were predictable many investors would use them to generate unlimited profits [3]. Their behavior would consequently cause market prices to adjust in the way that these abnormal returns disappear. Otherwise it would be possible to produce an unlimited wealth, which cannot occur in a stable economy [3]. In other words, due to timely actions of investors caused by new information stock prices quickly reflect all available information [4] and it becomes impossible for an investor to consistently earn excess return.

It is obvious that in a frictionless market in which all information is freely available and investors agree on its implications, the current price of security obviously fully reflects all available information [1]. The question is can the same conclusion be drawn on the imperfect market where real firms, investors and economy operate. Transaction costs, information that is not freely available to all investors and disagreement among investors about the implications of given information are not necessarily sources of market inefficiency, but it is important to measure their effect on the process of price formation [1]. Answers to the question are markets informationally efficient enables market participants to see what type of analysis, if any, is useful for forecasts of future prices.

With regard to which particular subsets of available information prices fully reflect three forms of market efficiency can be distinguished [1]. In a weak form of market efficiency market prices reflect all

historical prices and volume data and it is impossible to generate abnormal returns by using technical analysis. According to semi-strong of market efficiency securities' prices reflect all publicly available information. Therefore, both technical and fundamental analyses are not able to produce excess return. Finally, strong form of market efficiency assumes all information, both private and public, is reflected in securities' prices and even insider information cannot generate abnormal returns.

In accordance with above mentioned Fama's classification, weak-form efficiency of Croatian stock market is tested. The paper aims to answer on the question do market prices of the analyzed securities and stock index values follow a random walk or is it possible to forecast their future movement based on their past prices. It should also serve as an empirical test of Croatian capital market development and thereby as an indicator of potentially needed adjustments that would increase its efficiency.

Generally, weak-form efficiency tests are easier to run and more reliable then tests of semi-strong and strong form of market efficiency. Reason to that is the availability of necessary data. Nonetheless, the highest number of different tests can be used to test the usefulness of historical prices for future prices forecasting. The majority of them are based on the random walk hypothesis. Previous researche of stock market efficiency in Croatia rejected the presence of random walk in daily, weekly and monthly returns [5].

Testing of the weak-form market efficiency is performed by using the data on the daily historical returns of the Zagreb Stock Exchange market index (CROBEX) and of 6 index components. The basis of the tests used to confirm or reject weak-form efficiency of Croatian stock market is random walk model. Additional tests being used are autocorrelation tests, unit root tests and Wald-Wolfowitz run test. The possibility of time series modeling with the autoregression models has also been tested.

METHODOLOGY AND DATA

The basis of the test used to confirm or reject weak efficiency of Croatian stock market is random walk model. If returns follow a random walk it is not possible to forecast future prices on the basis of the previous ones and it can be stated market is weak form efficient. Tests being used are autocorrelation tests, unit root tests and Wald-Wolfowitz run test. The possibility of time series modeling with the autoregression model has also been tested. EViews is used as data analysis software.

To test weak-form market efficiency the daily data on historical returns of the Zagreb Stock Exchange market index (CROBEX) and returns of 6 stocks that are components of the index are used. The period covered is June 2010 to June 2015. In this way major price oscillation that occurred after Croatian economy entered recession in 2008 where avoided. The historical returns and not prices are used.

CROBEX is free-float weighted price index with dividends not accounted for calculation. It includes 25 stocks which have been traded at least 80% of the trading days. Weights of individual stocks are limited to 10%, index is calculated in real time and its composition is revised semiannually. Closing daily index values in the period starting in June 2010 and ending in June 2015 have been used.

Stock returns used in the tests are Ericsson Nikola Tesla, HT – Hrvatske telekomunikacije, AD Plastik, Atlantic Grupa, Podravka and Končar – Elektroindustrija. They represent different industries and are among most liquid index components. As for the market index data, closing prices of every trading day during the observed period have been used. Since these stocks belong to the group of the most liquid stocks in the market the test results for them should be similar to those for the market index.

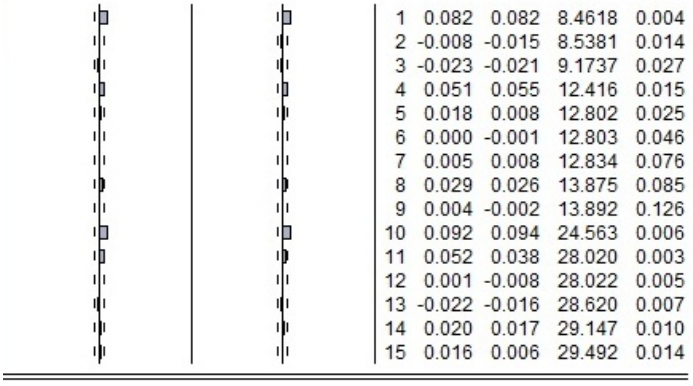
RESULTS OF THE ANALYSIS

Autocorrelation tests

Autocorrelation of the market index return and of the selected stocks return is analyzed by using correlelogram and than with Ljung-Box test. 15 lags on the daily returns were selected which is considered to be enough to detect serial correlation on lower and higher levels. Figure 1 represents correlelogram for CROBEX daily returns. Correlelogram analysis reveals significant autocorrelation on 1., 4., 10. and 11. lag. Positive autocorrelation prevails.

Figure 1. Correlelogram of CROBEX daily returns

Included observations: 1250



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.082	0.082	8.4618	0.004
		2	-0.008	-0.015	8.5381	0.014
		3	-0.023	-0.021	9.1737	0.027
		4	0.051	0.055	12.416	0.015
		5	0.018	0.008	12.802	0.025
		6	0.000	-0.001	12.803	0.046
		7	0.005	0.008	12.834	0.076
		8	0.029	0.026	13.875	0.085
		9	0.004	-0.002	13.892	0.126
		10	0.092	0.094	24.563	0.006
		11	0.052	0.038	28.020	0.003
		12	0.001	-0.008	28.022	0.005
		13	-0.022	-0.016	28.620	0.007
		14	0.020	0.017	29.147	0.010
		15	0.016	0.006	29.492	0.014

Source: Authors' analysis

However, at 5% significance level Ljung-Box test (Q-Stat) and p-value (Prob) show significant correlation on almost all lags. At the 1% significance level serial correlation in CROBEX time series cannot be rejected on 1., 10., 11., 12. and 13. lag. These results are supported with relatively low Q-values that are very close to critical values of χ^2 distribution with which they are compared. Further on, at 1% significance level the results of tests on logarithmic values of return time series confirmed significant autocorrelation on the 1., and 10. to 14. lag. At 5% significance level only insignificant autocorrelations are those on 7., 8. and 9. lag. It can be concluded there is significant autocorrelation of Crobex returns.

Returns on Ericsson Nikola Tesla and Hrvatski Telekom do not show significant autocorrelation but the direction on the existing autocorrelations differs – they are mainly positive for Ericsonn Nikola Tesla stock and negative for Hrvatski Telekom stock. Returns on AD Plastik stock show significant serial correlation on 10., 11. and 12. lag at 5% significance level. Returns on Atlantic Grupa, Končar – Elektroindustrija and Podravka stocks show significant serial correlation at each lag. The direction of the serial correlation is mostly negative in the case of Atlantic Grupa stock, equally positive and negative in the case of Končar – Elektroindustija stock and mostly negative in the case of Podravka stock.

The results of stock return analysis mainly confirm the conclusions drawn for CROBEX index. In that way first condition of the randow walk process on the Croatian capital market is partly compromised. Namely, if returns on Croatian stock exchange follow random walk they should not be autocorellated. Still, second condition – existence of unit root - is more important and therefore next step is the test of its existence.

Unit root tests

Tests on the existence of the unit root, tests the stationarity of the time series. If unit root exists time series are non-stationary and condition of random walk existence is fulfilled. Extended Diceky-Fullerovog test with Schwarz-Bayesov information criteria for lag selection is used. Constant term and trend were not included in test equations. As presented in the Table 1, all time series have unit root so one should not reject the hypothesis that analyzed time series are non-stationary. ADF t-test values calculated at 5% significance level suggest the same conclusion.

Table 1. Results of the extended Dickey-Fuller test

Time series	ADF test p-value	Critical p-value
CROBEX	0,6867	0,05
ADPL-R-A	0,6629	0,05
ATGR-R-A	0,6884	0,05
ERNT-R-A	0,6807	0,05
HT-R-A	0,6797	0,05
KOEI-R-A	0,6299	0,05
PODR-R-A	0,7236	0,05

Source: Authors analysis

Above presented results of unit root tests and extended Dickey-Fuller tests suggest the analyzed time series follow a random walk. Thus, they are in conflict with previously proven autocorrelation problem. Due to the additional checks in the form of Wald-Wolfowitz test are runned.

Walf-Wolfowitz *run* testa

Results of Walf-Wolfowitz*run* run test are presented in the Table 2. It is important to note that this test does not assume normal distribution of the analyzed data.

For the returns on CROBEX, Atlantic Grupa stock, Ericsson Nikola Tesla stock and Hrvatski Telekom stock the number of statistically significant runs is approximately equal to the number of expected runs. At 5% significance level stocks of AD Plastik and Podravka do not satisfy the null hypothesis of random walk. However, at 1% significance level returns on both stocks could be described as a random walk. P-value of sixth analyzed stock, Končar Elektronustrija, is extremely low. Based on these results one can not reject the hypothesis stating time series of analyzed returns are independent and Croatian stock market is weak efficient.

Results of the Walf-*Wolfowitzrun* test are further challenged by using the autoregression model to model returns on CROBEX market index. The results of that process significantly affect the final conclusion regarding weak form efficiency of Croatia stock market.

Table 2. Results of the Walf-Wolfowitz*run* test

	CROBEX	ADPL	ATGR	ERNT	HT	KOEI	PODR
μ	0,9999	1,0003	0,9999	1,0000	0,9996	1,0004	1,0002
n_1	623	570	685	580	633	506	575
n_2	627	669	545	669	620	654	660
E(R)	625,99	616,54	608,03	622,33	627,43	571,56	615,57
R	599	651	633	629	645	617	650
Z	-1,5276	1,9711	1,4431	0,3796	0,9931	2,7138	1,9693
Prob.	-0,8734	0,0487	0,1490	0,7042	0,3207	0,0067	0,0489

Source: Authors analysis; Note: μ je arithmetic mean of time series, n_1 is number of observations higher than μ, n_2 is number of observations lower or equal to μ, E(R) is expected number of *runs*, R is actual number of *runs*.

Result of the return modeling by using AR(p) model

If market is weak-form efficient it should not be possible to model return on market index by using autoregression model. Results of the modeling of CROBEX returns are presented in Figure 2.

Figure 2. Modeling of return on CROBEX Index by using constant term and AR(1) model

Dependent Variable: RCROBEX
Method: Least Squares
Date: 06/06/15 Time: 13:56
Sample (adjusted): 2 1250
Included observations: 1249 after adjustments
Convergence achieved after 2 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.999930	0.000224	4464.413	0.0000
AR(1)	0.082296	0.028243	2.913900	0.0036

R-squared	0.006763	Mean dependent var	0.999929
Adjusted R-squared	0.005966	S.D. dependent var	0.007286
S.E. of regression	0.007264	Akaike info criterion	-7.010112
Sum squared resid	0.065803	Schwarz criterion	-7.001897
Log likelihood	4379.815	Hannan-Quinn criter.	-7.007023
F-statistic	8.490811	Durbin-Watson stat	1.995626
Prob(F-statistic)	0.003633		

Inverted AR Roots	.08

Source: Author's analysis; Note: C is constant, AR(1) je autoregression model of the 1st order

Low p-values for both variables indicate the model is acceptable and returns on CROBEX can be modeled by using 1st order regression model. Still, according to R-squared only 0,68% of the variations of independent variable are explained by using this model. If lag of the depended variable is added in the model it becomes inappropriate since p-value of increases to 0,9997 and autocorrelation vanishes. In other words, although R squared does not change significantly in comparison to the first model presented, ARIMA(1, 1, 0) model or ARI(1, 1) model do not offer statistically significant estimates.

In the case of returns on sample stocks, autoregression model with constant term can not be used for AD Plastik, Ericsson Nikola Tesla and Hrvatske telekomunikacije stock, but it is useful for Atlantic Grupa,

Končar – Elektroindustriju and Podravka stocks. In the case of latter, R-squared ranges from 1.8% to 2.4% with lower values of information criteria, indicating a greater representativity of the model compared with the model for CROBEX.

CONCLUSION

This paper aimed to test the existence of the weak-form of market efficiency of Croatian stock market by testing the random walk hypothesis of the returns on CROBEX index and on 6 selected stocks. The hypothesis is tested by using autocorrelation test, unit root test and Wald-Wolfowitz run test. Possibility of return modeling by using autoregression model of first order is also tested.

The presence of a statistically significant autocorrelation of CROBEX returns and returns of 4 analyzed stocks indicated the likely absence of weak-form efficiency. However, extended Dickey-Fuller test confirmed unstationarity in analyzed time series indicating a random walk process and weak-form market efficiency. Walf-Wolfowitz *run* test is also performed. Its results, especially the test on CROBEX returns, are mostly in favor of the weak-form efficiency. Possibility to use autoregression model to predict returns is also tested. They showed it is possible to model returns with autoregression model but the conclusion is strongly relieved with the extremely low R-squared. Namely, autoregressioon model explains only 0,75% of return variations.

Based on the results of test undertaken it can be it hypothesis on the weak-form market efficiency of Croatian stock market can not be accepted, at least not completely. Still, due to extremely limited applicability of autoregression models tested it can be concluded market's weak-form efficiency is significant enough to disable realization of above-average earnings continuously. Although small and illiquid, Croatian capital market carries out its basic function.

When making the conclusion on the weak-form market efficiency certain limitations have to be taken into account. Observed period is limited to 5 years. Only closing prices where taken into account although it would be more appropriate to analyze every price change that occurs after the new information arrives. Liquidity premium is omitted from the analysis although it is significant on the Croatian capital stock market. Transaction costs where disregarded. These limitations show the need for further research of the hypothesis suggested in the paper.

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