Evaluation of Stocks from Zagreb Stock Exchange

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Abstract. *This paper deals with evaluation of chosen stocks from the Zagreb Stock Exchange based on data collected during the recent period.*
Twenty stocks have been chosen on the basis of their solvency and completeness of corresponding data. Stocks are compared to the official index of the Zagreb Stock Exchange CROBEX and compared mutually. For analysis of time series of prices for chosen stocks we used the methods of correlation, trend, and principal components analysis. Means and medians of change of stock prices were compared to mean and median values of CROBEX changes during the observed period of time.

Keywords. Zagreb Stock Exchange, technical analysis, statistics

1 Introduction

The aim of this paper is to find out how the changes of stock prices follow the changes of the stock market index CROBEX and to investigate dependence between stock prices and the CROBEX index. Our hypothesis is that magnitude and direction of the difference between changes of CROBEX and changes of prices for the specific stock could be a good predictor of stability and predictability of that stock. For experiment we have used the time series of stock prices in the period of half a year or 124 working days. Twenty stocks are chosen on the basis of their solvency and completeness of corresponding data. All of these stocks were included in the official index of the Zagreb Stock Exchange CROBEX in the beginning of the observed period, but some of them were discarded until the end of that period, because CROBEX was revised in the meantime.

Analysis of stocks using graphs of their prices is part of so called technical analysis. Unlike fundamental analysis of stocks which deals with business results of a firm in the past period of time, technical analysis deals only with prices and volumes of trading for a specific stock [2]. Here we will not use standard methods of technical analysis used for analysis of the Croatian stock market, but propose the usage of statistical methods appropriate for analysis of chosen stocks.

The Croatian stock market is one of the frontier markets that are developing in post-communist countries of east and southeast Europe. Characteristics of these markets are: a small number of stocks on the trade market, lack of transparency and solvency and short history of trading. There are no much publications dealing with statistical analysis of Croatian stock market. Risk of insolvency present in portfolio management on the Croatian stock market is investigated in [5]. In [10] authors are dealing with modeling of volatility of stocks on the Croatian stock market. Volatility of variable is a measure of its unpredictable change in a certain period of time. Research conducted on Croatian stock market reveals that small number of stocks present on Croatian stock market results by unsatisfactory level of portfolio diversification. Analysis on developed stock markets [1] and on Croatian stock market as well [10] shows that there is possibillity of predicting volatility of financial time series.

In this paper, time series of stock prices are analyzed by methods of correlation, trend and principal components analysis. Correlations between time series of prices for stocks are very high for all but one of the chosen stocks. Prices for all but one (the same one) stock are highly correlated with CROBEX as well. Principal component analysis of time series of prices reveals that there is only one

relevant component which is highly correlated with CROBEX. Time series of prices for each stock was modeled by exponential trend. It is shown that all prices of stocks (except one) and CROBEX had a decreasing trend in the observed period of time. As most of the stocks decreased in value during the chosen period, our intension was to investigate how changes of stock prices follow the changes of CROBEX. For that reason, means and medians of changes of prices are compared to the mean and median of change of CROBEX using the pared t-test (parametric) and the Wilcoxon matched pairs test (nonparametric). We suggest the usage of p-value of mentioned tests as a measure of similarity between CROBEX and time series of prices for the specific stock.

The paper is organized as follows: in the second section we offer an inside look at methods used for the analysis, in the third section we describe the data set, while in the forth section we describe experiments and give numerical results. The last section contains conclusions and directions for further research.

2 Methods

2.1 Exponential trend

In order to measure dependence between prices for chosen stocks, we used methods of correlation and one-dimensional exponential trend [7].

One-dimensional exponential trend models trend of variable Y by relation

$$Y_i = AB^{t_i} \tag{1}$$

where $i = 1,2,\ldots,n$ are observations and t_i is the variable of time. The parameter B indicates the relative change in dependent variable Y given a unit period of time.

Coefficient of determination r^2 is defined as ratio of variation of data explained by the model and total variation of data. The parameter of r^2 and its root square coefficient of correlation r are used as a measure of fit of original data to the model. The coefficient of correlation r assumes values between -1 and 1.

2.2 Principal components analysis

The principal components analysis provides insight into the most relevant factors around which variables are grouped [8]. It allows expressing large proportion of total variance of data with smaller number of variables in directions of maximum variation of data. The first principal component is the linear combination of original variables with maximum variance, the second principal component is the linear combination with maximum variance orthogonal to the first component and so on.

2.3 Methods for comparison of means and medians for two dependent samples

Difference of mean values of two dependent samples is tested by the parametric method of the t-test for matched pairs, while the difference of medians of two dependent samples is tested by the nonparametric Wilcoxon match pairs test [7,11]. Here we will test if there is a difference between daily change of stock price for the chosen stock and daily change of the CROBEX index. Daily change of stock price (or CROBEX) is calculated by formula

$$c_i = \frac{p_{i+1} - p_i}{p_i} \tag{2}$$

$i = 1,2,\ldots,n-1$ where n is the total number of data in the time series and p_i is the price on the i-th day. Let $d_i, i = 1,2,\ldots,n$ be differences of pairs for two samples. The sample mean of paired differences is given by

$$\overline{d} = \frac{\sum d_i}{n}, \tag{3}$$

while the estimated standard error of $\overline{d}$ is given by

$$S_{\overline{d}} = \sqrt{\frac{\sum d_i^2 - \left(\sum d_i\right)^2}{n-1}}. \tag{4}$$

When the population of differences is normally distributed, the statistic given by

$$t = \frac{\overline{d} - \mu_d}{S_{\overline{d}}} \tag{5}$$

has a t-distribution with (n-1) degrees of freedom. In Eq. 5, μ_d is the difference of paired populations assumed by hypothesis.

The Wilcoxon match pairs test is the nonparametric alternative to the paired t-test. Usually, the Wilcoxon match pairs test is less powerful then the t-test when assumptions on normality of differences are satisfied. Like the other nonparametric tests, this test substitutes original data by its rank and, because of that, it loses part of the information present in it. Absolute values of differences between the corresponding pairs d_i are ranked in ascending order. The sign of the difference is associated with each difference. Let T_+ be the sum of the positive differences, T_- the sign of the negative differences and $T = \min\{T_+, T_-\}$. The normal approximation procedure (or z-test) is used when $n_0 > 15$ where n_0 is number of non-zero differences. The test statistic is

$$z = \frac{(T + 0.5) - \mu_T}{\sigma_T} \tag{6}$$

where

$$\mu_T = \frac{1}{4} n_0 (n_0 + 1) \quad (7)$$

and

$$\sigma_T = \sqrt{\frac{1}{24} n_0 (n_0 + 1)(2n_0 + 1)} \ . \quad (8)$$

3 Data set

The experiments are conducted on the data set of time series of prices of twenty chosen stocks from Zagreb Stock Exchange in the period from 8th November 2007 to 9th May 2008. Stocks are chosen on the basis of their solvency and completeness of corresponding data. . Our research included stocks from the food industry sector (Franck, Kraš, Podravka), tourism (Arenaturist, Rabac, Istraturist, Sunčani Hvar), electrical industry (Dalekovod, Ericsson Nikola Tesla, Končar, Tehnika), shipbuilding (Atlanska plovidba, Tankerska plovidba, Uljanik plovidba), civil engineering (Institut građevinarstva Hrvatske, Vijadukt) and the financial sector (Centar banka, Croatia osiguranje, Hrvatska poštanska banka, Karlovačka banka). At the beginning of the observed period all of the chosen stocks were included in CROBEX, but by the end of the period some of them were discarded. Revision of CROBEX is regularly carried out twice a year, on the third Friday in March and September. Basically, criteria for inclusion of stock to CROBEX are connected to their solvency. The first column of Table 1 contains the label of the stock[1]; in the second is the stock issuer; and the third contains information whether the stock was included in CROBEX at the end of the observed time period.

4 Experiment and results

Time series of stock prices for most of the chosen stocks are mutually highly positively correlated. The exception is the stock ISTT, which has low negative correlations with almost all other stocks. Also, correlations between CROBEX and chosen stocks are generally higher then 0.5, but many of them are even higher then 0.9 ($p<0.05$). For the stock ULPL, correlations between other stocks and CROBEX are somewhat lower then for other stocks.

Results of experiments using method of principal components analysis are in line with high correlations between time series of prices. Table 2 shows loans of variables (time series of chosen stock prices) in the first two principal components, which account for 88.9% of data variation. The first principal component alone accounts for 82.2% of data variation.

[1] Proper labels of chosen stocks from Zagreb Stock Exchange should be NAME-R-A. Here we use shorter labels in the sake of simplicity of notation.

Table 1. List of stocks chosen for experiment. The first column marks the stock labels, the second lists stock issuers and the third contains the information whether the stock was included in CROBEX at the end of the observed time period (all the stocks were included in the beginning).

Label	Issuer	In CROBEX
ARNT	Arenaturist d.d.	No
ATPL	Atlanska plovidba d.d.	Yes
CEBA	Centar banka d.d.	No
CROS	Croatia osiguranje d.d.	Yes
DLKV	Dalekovod d.d.	Yes
ERNT	Ericsson Nikola Tesla d.d.	Yes
FRNK	Franck prehrambena industrija d.d.	No
HPB	Hrvatska poštanska banka d.d.	No
HRBC	Rabac, ugostiteljstvo i turizam d.d	Yes
IGH	Institut građevinarstva Hrvatske d.d	Yes
ISTT	Istraturist Umag, hoteljerstvo i turizam d.d	No
KABA	Karlovačka banka d.d.	No
KOEI	Končar – elektroindustrija d.d.	Yes
KRAS	Kraš prehrambena industrija d.d.	No
PODR	Podravka prehrambena industrija d.d.	Yes
SUNH	Sunčani Hvar d.d.	No
THNK	Tehnika d.d.	Yes
TNPL	Tankerska plovidba d.d.	Yes
ULPL	Uljanik plovidba d.d.	Yes
VDKT	Vijadukt d.d.	Yes

There is only two eigenvalues greater then 1; the first one has the value of 16.43 and second 1.34. Loans of all variables except variable of ISTT stock are large in the first component. We can say that all stocks except the stock of ISTT belong to the first component. The last row of the table shows the correlation of components to CROBEX. The first component is highly correlated with CROBEX, while the second component is not correlated to CROBEX at all. In the second component, only the stocks of ISTT and ULPL have greater loans, but the stock of ULPL have great loan in the first component as well. Generally, we can conclude that in the first component are stocks which follow the CROBEX index well, while in the second component are stocks whose correlations with CROBEX are lower. The stock of ULPL is limit case belonging to both components.

Table 2. Loans of variables (time series of prices of chosen stocks) in the first two principal components. The last row shows the correlation of the components to CROBEX.

Stock	1st component	2nd component
ARNT	-0.9343	0.1773
ATPL	-0.9127	0.1061
CEBA	-0.9748	0.0513
CROS	-0.9463	-0.1225
DLKV	-0.9904	0.0065
ERNT	-0.8464	0.0574
FRNK	-0.9614	-0.0192
HPB	-0.8098	-0.0595
HRBC	-0.8847	-0.0965
IGH	-0.8589	-0.3092
ISTT	0.3305	-0.8848
KABA	-0.9550	0.0850
KOEI	-0.9824	-0.0208
KRAS	-0.9871	0.0096
PODR	-0.9606	0.1404
SUNH	-0.9515	0.0862
THNK	-0.9875	-0.0346
TNPL	-0.9864	-0.0200
ULPL	-0.6245	-0.5928
VDKT	-0.9768	0.0110
CROBEX	-0.9878	-0.0530

We have modeled the trend of time series of prices for every stock by means of exponential trend in order to obtain the average value of the relative change in prices. The value of the trend of average change rate is computed as

$$s_B = 100 \cdot B - 100 \qquad (9)$$

where B is the parameter in exponential trend (Eg. 1). The values of s_B for chosen stocks are given in the second column of Table 3, where one can see that all stocks and CROBEX except the stock of ISTT have a decreasing trend. In the brackets are values of r^2 which give information about trend fitting. r^2 values are greater then 0.5 in absolute value for trend models of all stocks except for stocks of ERNT, IGH, ISTT and ULPL. Two out of four stocks with lower r^2 value belong to the second principal component whose correlation with CROBEX is low.

The rest of our research was focused on the investigation of how changes of stock prices follow the changes of CROBEX. Mean values of changes of stock prices are shown in the third column of Table 3, while the medians are shown in the fifth column of the table. All mean values are negative except for ISTT and all median values are not positive. It is interesting to note that 10 median values are zero (to four decimal places) and another two are less than 0.001 in absolute value.

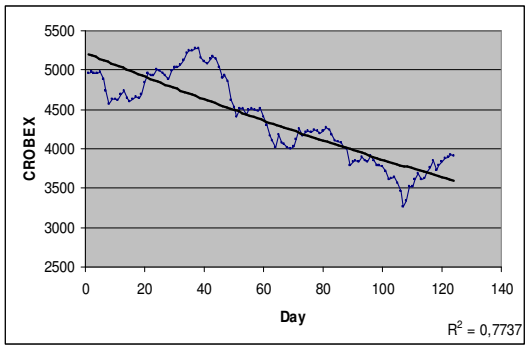

Figure 1 a. CROBEX and approximation by exponential trend.

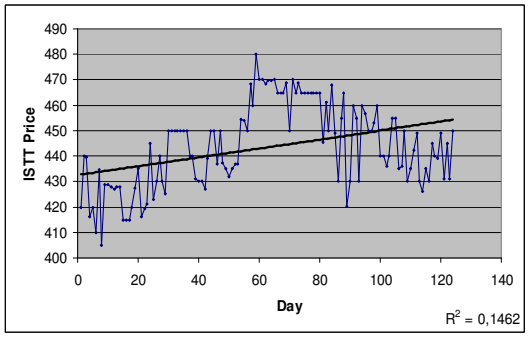

Figure 1 b. Prices of ISTT stock and approximation by exponential trend.

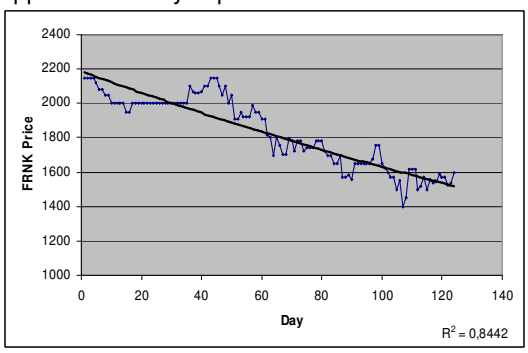

Figure 1 c. Prices of FRANK stock and approximation by exponential trend.

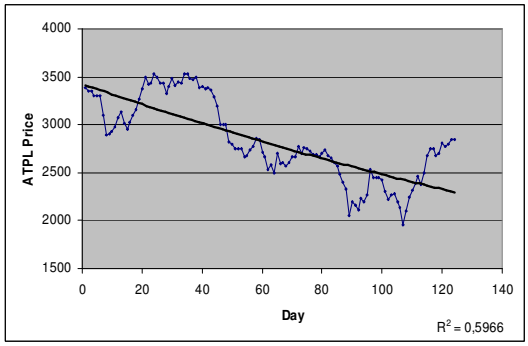

Figure 1 d. Prices of ATPL stock and approximation by exponential trend.

Table 3. Characteristics of chosen stocks. The second column shows the rate of average change of trend value of prices (in the brackets are r^2 values); the third and fifth columns show measures of central tendency (mean and median) for price changes of chosen stocks and change of CROBEX; the forth column contains standard deviations of changes; the sixth and seventh columns show p-values of the t-test and the Wilcoxon match pairs test.

Stock	s_B (%) (R^2)	$\overline{X}$	σ	Me	t-test p-value	Wilcoxon p-value
ARNT	-0,40 (0,7616)	-0,1031	5,6656	0,0000	0,8481	0,9057
ATPL	-0,32 (0,5966)	-0,0884	3,3084	-0,0003	0,5745	0,9543
CEBA	-0,60 (0,9328)	-0,4531	2,7447	0,0000	0,3512	0,6481
CROS	-0,34 (0,8419)	-0,2886	3,3070	0,0000	0,7361	0,4278
DLKV	-0,55 (0,8082)	-0,2561	3,3083	-0,3495	0,7424	0,5151
ERNT	-0,16 (0,4343)	-0,0793	2,1630	-0,0002	0,4034	0,5663
FRNK	-0,29 (0,8442)	-0,2000	2,7847	0,0000	0,9874	0,9668
HPB	-0,22 (0,7085)	-0,2621	3,4766	0,0000	0,8426	0,8811
HRBC	-0,35 (0,7990)	-0,2669	3,1297	0,0000	0,8154	0,8234
IGH	-0,26 (0,4401)	-0,0711	3,6894	-0,1700	0,5681	0,7102
ISTT	0,04 (0,1462)	0,0870	2,8678	0,0000	0,3112	0,2602
KABA	-0,45 (0,8737)	-0,2793	3,8320	0,0000	0,8257	0,8536
KOEI	-0,48 (0,7586)	-0,3005	2,9441	-0,4422	0,5217	0,3210
KRAS	-0,44 (0,8532)	-0,3093	3,2801	-0,2369	0,6349	0,4163
PODR	-0,26 (0,7916)	-0,1576	2,0805	0,0000	0,8384	0,7326
SUNH	-0,34 (0,8413)	-0,1532	3,8171	0,0000	0,8982	0,9682
THNK	-0,70 (0,8556)	-0,3483	3,9278	-0,0321	0,6025	0,2070
TNPL	-0,50 (0,8556)	-0,3593	3,4295	-0,0186	0,4797	0,3446
ULPL	-0,33 (0,3618)	-0,2426	4,4429	-0,0411	0,8943	0,9722
VDKT	-0,60 (0,7441)	-0,2578	4,3906	-0,0762	0,8465	0,3472
CROBEX	-0,30 (0,7737)	-0,1961	1,7534	-0,0200		

Based on the change median value, it is possible to give some estimation of the standard measure of technical analysis called the relative strength index (RSI), which depends on the ratio of stock price increase/decrease days. Namely, the median of zero tells us that the number of days when the stock rose is exactly the same to the number of days when the stock fell. Negative value of the median is an indication of more days when the stock fell and its positive value is indication of greater number of days when the stock rose. In our case, half of the chosen stocks had the same number of days of stock value increase and stock value decrease. For the rest of the chosen stocks, prices during the observed period more often decreased. Additionally, the zero value of the median and negative mean value of stock price changes indicates that drops were larger than increases in absolute value for such a stock.

The sixth column of Table 3 shows p-values of the t-test, where differences between mean values of stock prices changes and mean values of CROBEX are tested. It shows that there is no significant difference between mean values of changes and changes of CROBEX for any of the chosen stocks at the 0.05 level of significance. The reason for that are high values of standard deviations (relative to mean values) shown in the forth column of Table 3. According to χ^2 test, sample differences between changes of stock prices and changes of CROBEX are not normally distributed for any of the chosen stocks. This is indication that the t-test for paired samples should not be applied. Nevertheless, in case of large samples $(n \geq 30)$, as was used in our experiment, t-test is good approximation of z-test for which the normality of distribution is not necessary condition [9]. In order to obtain more reliable results we have also applied the nonparametric test of Wicoxon mach pairs. The seventh column of Table 3 shows p-values of the Wicoxon mach pairs test, testing the differences between price change medians for stocks and changes of CROBEX. According to p-values, there is no significant difference between price change medians for chosen stocks and median of changes of CROBEX. The correlation coefficient between p-values for the t-test and p-values for the Wilcoxon mach pairs test has the satisfactory value of 0.588 ($p<0.05$). Although there is no significant difference between means and medians, p-values of respective

tests can be interpreted as measures of similarity between changes of stock prices and changes of CROBEX. In Figure 1 a the graph shows the value of CROBEX and its approximation by exponential trend. Figures 1 b-d show price graphs of some of the chosen stocks and their approximation by exponential trend (b-ISTT, c-FRNK, d-ATPL). According to p-values of the t-test and the Wilcoxon match pairs test, the ISTT stock is one of the stocks that most differs from CROBEX based on their relative changes, while FRNK is one of the stocks most similar to CROBEX. The ATPL stock is very similar according to the Wilcoxon match pairs test, but not so similar according to the t-test. Nevertheless, the price change graph looks very similar to the CROBEX graph. The reason for that probably lies in the fact that the t-test operates with numerical values, while the Wilcoxon match pairs test operates with ranks.

5 Conclusions and discussion

Most stocks observed in the allotted time period shared a similar dynamic with that of CROBEX, which seems to be good indicator of the state of matters on the Zagreb Stock Exchange. Time series of stock prices for most of the chosen stocks are mutually highly positively correlated and they are highly correlated to CROBEX as well. This resulted by only one relevant principal component which represents time series of prices for all but one chosen stock and which accounts for 82.2% of data variation.

Our hypothesis is that such a state is the results of the following frontier market characteristics: a relatively small number of stocks on market and the lack of solvency. These conditions cause big investors (pension founds) to concentrate on a small number of solvent stocks because they can not afford the risk of greater diversification of their portfolio. Prices of the most solvent stocks then depend strongly on current (financial) situation of big investors. According to some academic papers [3,6] international diversification of portfolio could have positive effects.

The trend of time series of prices for every stock was modeled by means of exponential trend. Average value of the relative change in prices for almost all stocks showed that prices were decreasing in observed period of time. The major research focused on investigation of how changes of stock prices follow the changes of CROBEX. It was shown that there is no significant difference between means and medians of changes of stock prices and changes of CROBEX for all chosen stocks. Her we suggest that p-values of respective tests can be interpreted as measures of similarity between changes of stock prices and changes of CROBEX.

In further work, we plan to expand our research by methods of clustering and classification, and perform more detailed research by comparing stocks from the same sector. In addition to prices of stocks, data concerning volumes of trading and parameters of fundamental analysis could be included in the research. Further, similar research could be conducted on other stock markets in order to compare results with the results of this research.

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