The Information System for US Stock Market Fundamental and Technical Analysis

Sergejs HILKEVICS
Faculty of Economics and Business Administration, Ventspils University College
Ventspils LV-3600 Latvia
e-mail: sergejs.hilkevics@venta.lv

Galina HILKEVICA
Faculty of Information Technologies, Ventspils University College
Ventspils LV-3600 Latvia
e-mail: galina.hilkevica@venta.lv

ABSTRACT

Fundamental and technical analysis are two main methods of forecasting in economics, securities analysis and investments. Fundamental analysis is based on the consideration of those factors, which influence economic process. Technical analysis is the method of economic analysis, which is based on the previous history of the process analysis and does not consider influencing economic factors. Technical and fundamental analysis approaches are so different, that TA and FA can be considered as relatively independent methods.
As study courses, technical and fundamental analysis are included in study programs of faculties of economics and business administration in many European and American universities. Usually such courses consist of theoretical lectures and practical exercises. Sufficient help for fundamental and technical analysis course realization can provide specialized information system. The creation of such system is complicated task, because there are specific requirements for information systems for study courses in fundamental and technical analysis support. Such information systems should be complete enough – it should contain all necessary procedures for information processing, which are sufficient for investment portfolio creation and investment decision making. Appropriate procedures include input data receiving, data pre-processing, stocks screening, optimal portfolio creation, portfolio testing and correcting. Information system should be simple enough and understandable for students of economics and business administration. Information system should be flexible and provide the possibility to change algorithms of data processing from simple to complicate. Information system should be extendable and ensure the possibility to use it for research work and practical investment activities. Information system should be based on appropriate IT platform and use appropriate programming language.
The paper is devoted to the description of information system created at the Ventspils University College during last 10 years to support the study course in stock market fundamental and technical analysis. Results received using this system for US stock market and possible practical applications are considered also.

Keywords: information system, fundamental analysis, technical analysis, stock market, portfolio optimization.

1. INTRODUCTION

This paper is devoted to the consideration of information system, which was created at the Ventspils University College for the study course “Stock market fundamental and technical analysis” support.
The main theoretical goal of the course is to explain to students of faculty of economics and business administration the theoretical principles of fundamental and technical analysis, and demonstrate the implementation of these principles for economic situation analysis. The main practical goal of the study course is to teach students how to create good investment portfolio from stocks available at stock market. The main task of information system is to realize all data processing procedures, which are necessary for theoretical market analysis and practical tasks solution, including investment portfolio creation.
Study course consists of 24 lectures and 24 practical exercises in computer class and is oriented for 3-4 year students of bachelor program in economics and business administration with specialization in finances. To reach above mentioned theoretical and practical goals of the study course, it is necessary to consider at lectures theoretical foundations and perform at practical works in computer class all data processing procedures, necessary for investment portfolio creation - fundamental and technical data receiving, data pre-processing, stocks selection, portfolio optimization, testing and correction.
There are several specific requirements for information systems for study courses in fundamental and technical analysis support. At first, such information system should be complete enough – they should contain all necessary information-processing procedures, which are sufficient for investment portfolio creation and investment decision making. These procedures include input data of different kinds receiving, data pre-processing, stocks screening, optimal portfolio creation, portfolio testing and correcting.
At second, information system should be simple as possible and understandable for students of economics and business administration, who are not IT specialists. It is necessary to take into account that students of economics and business administration have no programming skills and experience in working with databases.
At third, information system should be flexible and provide the possibility to substitute the simple algorithms of data processing by more complicated. This requirement is very important from methodological point of view because many theoretical

questions, especially in technical analysis, is necessary to explain for students several times – on the introductory level for the initial understanding, on the base level for core understanding and on the advanced level for research work and practical applications. It is not recommended to explain complicated things in their full complexity for beginners. Experience shows that from educational point of view it is better to divide complicated things into several relatively simple parts, consider them separately and join them together only when they are clear enough for students. It means that information system, which support study course, should be modular – it should consist of separate modules, which can be easy combined together by user. The modular structure of information system makes it extendable also – new modules can be added to system in any time. These modules can be complicated enough to make research work and use the system in practical investment activities.

At fourth, information system should be based on appropriate IT platform and use appropriate programming language. The development of system under consideration started 10 years ago from the set of laboratory works for economics students. Initially laboratory works were based on Visual Basic for Application (VBA), because VBA is build into Excel and at that time it seemed more convenient for students of economics and business administration, who does not know C++ and C# , to use VBA. But after some time it became clear that VBA is not appropriate enough for information system creation - it was easy to create separate simple programs, but difficult to integrate them into information system, it was possible to create simple own code, but there was no financial analysis libraries. After attempt to use VBA as programming language for laboratory works, Matlab was selected as programming platform and this decision was much more successful, especially after separate course in Matlab introduction in study program for economists.

There are several advantages for Matlab use instead of VBA for financial information system development. At first, there are Financial Toolbox and Financial Instrument Toolbox in Matlab with the libraries of standard financial functions. At second, due to structural approach to programming, which is used for system development, scripts are easier for understanding to students than object-oriented programming. The same course for IT students and information system for it support could be created by completely different way, but for students of economics programming procedures should be as simple as possible. At third, Matlab scripts can use other scripts and this is very convenient for modular approach to information system creation. By this way students can easy construct complicated information processing procedures from more than 150 relatively simple Matlab scripts by themselves.

The functionality of system is based on the following data processing procedures:

1. Fundamental data receiving
2. Technical data receiving
3. Data pre-processing
4. Fundamental data analysis
5. Technical data analysis
6. Stocks selection
7. Portfolio optimization
8. Portfolio testing and comparing
9. Portfolio corrections

Let us consider these procedures in details now.

2. FUNDAMENTAL DATA RECEIVING

Fundamental analysis is the economic forecasting and company valuation method, which considers economic and financial factors influencing securities values. Fundamental analysis considers as general macroeconomic factors influencing economy, so and financial ratios of separate companies. The main task of fundamental analysis is to investigate company's financial and economic ratios to identify problematic aspects of development and work out recommendations to increase value of company. Very often fundamental analysis is used in investments to estimate so called "fair stock value". Comparing fair stock value, which is determined by expected future cash flows, with the stock current market value it is possible to decide whether this stock is the attractive for investment. The stock is attractive for investment if fair value is higher, than current market price.

For company valuation fundamental analysis needs fundamental data which can be received from company's financial statements. There are three main financial statements, where from financial ratios can be received – balance sheet, profit and loss statement, cash flow statement.

There are two main sources where financial statements of companies are available. The first source is the Stock Exchange. In accordance with financial markets regulating laws all public companies, which attract the public funds should present to Stock Exchange the quarterly financial reports and stock exchanges should provide free access to these data. Unfortunately, in Europe Stock Exchanges reports are often presented in *.pdf format and it is difficult to extract quantitative values from such reports. The main reason of this difficulty is that XBRL format is not accepted as standard in Europe yet – e.g. in Latvia it will be in force from January 1, 2020.

The second source where financial statements are available is the national Security and Exchange Commissions. The information system EDGAR of U.S. Security and Exchange Commission contains 21 million filled reports - US stock companies quarterly financial reports starting from 1934. EDGAR provides data from US companies quarterly balance sheets, cash flows and profit-loss reports in HTML, XBRL, XLS formats, which is very convenient for further information processing. The possibility to receive all necessary information in convenient form is the main reason why our study course and supporting information system use mostly US stock market data. It impossible to receive similar information in Europe at present time. In addition, EDGAR is very friendly system, it allows data downloading free of charge. Our information system uses more than 100 GB of information received from EDGAR with fundamental data about US stock companies.

Depending on the purpose of research, fundamental data usually are arranged in different groups. In the first approximation, the most often used ratios are related with the profits, assets and growth of company. In the second approximation there are such groups of ratios as asset utilization, operating performance, cash flow, liquidity, capital structure and solvency, return on investment, market performance, structural units and departments performance measurements, which provide more detailed information about the company.

For the study course needs we consider in our information system such groups of fundamental data as general data, per share data, dividends, valuation data, financial strength, earnings, margins, management effectiveness, growth with the following ratios:

Ratio	Formula
High price	Highest price of period
Low Price	Lowest price of the period
Market Capitalization	Shares outstanding *Share Market Price
Per share data	
EPS	Earnings per share
Revenue per share	Net sales / Shares outstanding
Book value	Shareholder's Equity / Shares Outstanding
Cash per share	Cash or equivalents / Shares Outstanding
Dividends	
Dividends per share	Cash dividends declared per share
Dividends yield	Cash dividends declared per share / Stock current market price
Valuation	
P/E	Market Value per Share / Earning per Share
P/S	Market Capitalization / Annual Total Sales
P/B	Stock Price / Book Value per share Book value = Total Assets - Total Liabilities Book value per share = Book value / Shares Outstanding
Price/Cash	Stock Price / Latest quarter Cash per Share Cash per Share = (Cash + Short-term marketable securities) / Entity Common Stock Shares
Price/Free Cash Flow	Market Capitalization / Free Cash Flow Free Cash Flow = Cash Generated by operating activities - Capital expenditures
Financial strength	
Current Ratio	Current Assets / Current Liabilities
Quick Ratio	(Current Assets – Inventories) / Current Liabilities (Cash + marketable securities + accounts receivable) / current liabilities
LT Debt/Equity	Long-term debt / Shareholders' Equity Shareholders' Equity = Total assets - Total liabilities
Debt/Equity	Total Liabilities / Shareholders' Equity
Payout Ratio	Dividends Per Share (DPS) / Earnings Per Share (EPS)
Earnings	
Revenue	Total sales
EBIT	Income before provisions for income taxes
EBIDT	EBIT (Income before provisions for income taxes) + Depreciation and amortization
Net Income	Net income
Margins	
Gross Margin	(Total Revenue - Costs of Goods sold) / Total Revenue * 100
Operating Margin	Operating income / Total revenue * 100
Net Profit Margin	Net income / Net sales *100
Pre-tax Margin	Earnings before taxes / Net Sales*100
Management effectiveness	
Return on Assets	Net income / Total Assets
Return on Equity	Net Income / Shareholder's Equity
Return on Investment	(Gain from Investment - Cost of Investment) / Cost of Investment
Growth	
Revenue change %	Q to Q or Y to Y
Revenue growth %	Last 5 Y
EPS growth %	Q to Q or Y to Y
Growth rate %	Dividend per share growth last 5 years

The determination of amount of fundamental parameters, which are necessary to describe the company, is complicated task. Form one side, increasing amount of company describing parameters we receive more information. From the other side, to analyze system with many parameters is more difficult, than with few parameters. The similar situation is with the mathematical models in economy in general – increasing amount of describing parameters exactness of model at first grows, but after that decreases, because for real economies it is impossible to determine exact values of all parameters used in models.

The complete system of financial ratios is described in US GAAP Financial Reporting taxonomy, which contains more than 13 000 terms and describes relations among them. The last version "The 2018 US GAAP Financial Reporting Taxonomy Including Taxonomy Disclosure Templates" can be accessed at FASB home page www.fasb.org.

For the purposes of study process our information system uses approximately 60 primary financial ratios, which can be received from the balance sheet, profit-loss statement and cash flow, such as Total Assets, Fix Assets, Current Assets, Owner Funds, Long Term Loans, Current Liabilities, Capital Employed, Working Capital, Net Worth, EBITDA, EBIT, EBT, EAT, ROTA, ROI, ROE. For research purposes amount of parameters, which can be extracted from EDGAR, can be increased until 100 – 200 and additional parameters, which are not included in EDGAR, can be calculated.

Later these fundamental data will be used for analysis and stocks selection.

3. TECHNICAL DATA RECEIVING

Technical analysis is the method of securities analysis that is based on the statistical analysis of prices movements. Simplest technical analysis methods are known as charts analysis and consider the charts of historical prices to identify trends, continuation and reversal patterns, supports and resistances. More complicated technical analysis methods use technical analysis indicators – Moving Averages MA, Moving Averages Convergence Divergence MACD, Stochastic, Relative Strength Index RSI, On Balance Volume OBV, Bollinger Bands BB, Directional Movement Index DMI and others. There are about 50 widely known, popular and often used indicators, about 300 indicators used by such trading systems as Metastock, about 2500 indicators described in literature. On the base of technical indicators traders, software like Metastock create trading systems which forecast future price changes and work out recommendations to enter market and step out. Advanced technical analysis methods use for forecasting such methods as data mining, genetic algorithms, neural networks, kinetic equations, econophysics. Our information system use technical data for portfolio optimization, testing and corrections.

Technical data – stock prices time series - can be received from servers finance.google.com and finance.yahoo.com using Matlab function fetch by the following way:

```
function [ HistoricalPrices, Failed ] = getHistoricalPrices( Symbols, PriceType, FromDate, ToDate, Period )
%% Download historical prices from Yahoo Finance servers

% Initialize variables
h = waitbar(0,'Prepearing to download data from Yahoo Finance');
Server = yahoo;
Failed = {};
n = length(Symbols);

% Try to download data
for i = 1:n
  try
    HistoricalPrices.(Symbols{i}) = fetch(Server, Symbols(i), ...
      PriceType, FromDate, ToDate, Period);
    % Update waitbar
    waitbar(i/n, h, ['Downloading historical prices for ' Symbols{i}]);
  catch exception
    % Make list of undownloaded data
    Failed = [Failed; Symbols(i)];
    continue
  end
end
close(h)
end
```

There are certain difficulties with technical data receiving. For many years, the main source of technical data for academic needs was server finance.google.com, which provided daily stock prices free of charge. At present time this service is closed and our system receives stocks historical prices from yahoo.com. At present time we have daily high, low, close, adjusted prices for more than 6000 US stocks approximately for 20 last years.

4. DATA PRE-PROCESSING

As technical so and fundamental data received from financial servers contain different errors - missing data, wrong values, NaN (Not a Number), so the correction of the data is necessary. Correction of technical data is more simple and is performed using interpolation, extrapolation and Tikhonov regularization. If missing data are found in middle of time interval and length of missing array is not more than several days, then than recovery of the data is made using linear interpolation from the last known to the new values. If missing data are found at the beginning of period and the amount of missing data is not very large the recovery of the data is made using reversal linear extrapolation of following values. If missing data are found at the end of period, the recovery of the data is made using linear extrapolation of previous values. If there is relatively large amount of missing data in time series, the minimum of Tikhonov functional

$$F=\int_a^b (y-f)^2 dx + \propto^2 \int_a^b (y')^2 dx \rightarrow \min \quad (1)$$

should be found, where f(x) is the approximation of initial array with zeros instead of missed data, y(x) is the approximation of restored data array. The parameter α is “smoothing” parameter – if $\alpha = 0$ the minimum of functional is reached when $y(x) = f(x)$, if $\alpha \neq 0$ y(x) is the smoothed approximation of f(x). Similar results can be received using Kalman filtering or SSA (singular spectral analysis), but they are more complicated for explanation to economists than Tikhonov regularization.

If there is no possibility to recover data using previously mentioned correction methods, tim**e** series are excluded from further consideration. For the short 3-5 years’ time intervals there is less than 5-10% of stocks which are excluded from consideration for this reason.

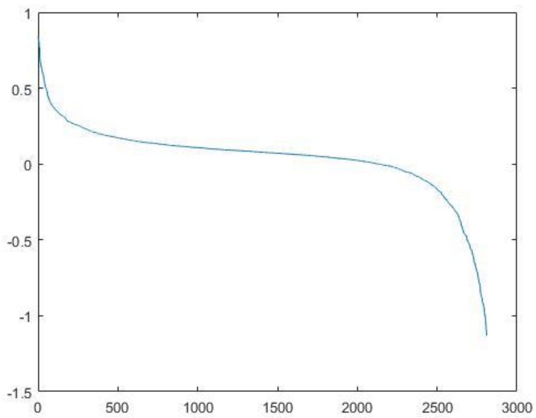
More complicated technical data processing problems are related with such market effects as splits. Mostly due to marketing reasons, when the price of stock seems to the management of company as too high, company makes “split” - decrease price of stock several times increasing the same time amount of them for each owner. This procedure does not influence the market capitalization of company, but the market price of stock decreased several times. All methods of portfolio optimization are very sensitive to such in reality not existing changes of price. For certain period the consideration of adjusted price instead if market price can help, but this cannot be continued forever and serious corrections of past stock prices are necessary.

Missing fundamental data corrections are more problematic than technical data corrections. At first, it is necessary to divide fundamental data into 12 levels according to US GAAP taxonomy. At second, it is necessary to check the possibility to calculate n-level missing ratio from known n+1 level ratios – there are cases when this is possible. At third, it is possible to compare EDGAR data with source reports – sometimes it helps, because there are cases, when initial *.pdf sources contain data, which are not included in *.xml.

Unfortunately, there are no good universal methods to correct fundamental data and almost in each case it is necessary to make special investigation about the previous and following financial ratios.

5. FUNDAMENTAL DATA ANALYSIS

As it was told above, there are more than 100 primary financial ratios, which can be received from companies' financial statements.



Pic. 1. ROA distribution for US stock companies Q4/2017

The first useful task which can be solved using fundamental data is the ratios distributions analysis. Pic. 1 contains the ROA distribution for 3000 US stock companies for Q4/2017. For 2313 of them (77%) ROA is positive, the average value of ROE is 0.0414. The percentage of companies with positive ROA in US is higher, than in Europe. By the same way distribution for other primary ratios, e.g. ROI, ROA for different US economy sectors can be received. The comparison of company ROI, ROA, ROE with average values is important, because according to strategic management theory company is competitive only if returns are higher than average in industry.

The second useful task which can be solved using fundamental data is the correlations analysis. Correlation coefficients between stock prices and key ratios for 24 quarter reports for 840 Russell 1000 stocks for last 6 years looks as follows:

Ratio	Ratio_ID	Cor_Coef_Price_Ratio
"Price"	5	1
"Cap"	36	0.930248273
"P/B"	43	0.685519731
"SP500"	6	0.62537219
"P/C"	44	0.491594069
"Assets"	13	0.425039381
"P/S"	42	0.403737497
"RetEarn"	28	0.39571759
"Liab"	23	0.352985886
"Equity"	10	0.326194468
"FixAsset"	14	0.294808878
"Reciev"	24	0.286662746
"LiabC"	21	0.285237574
"Book/sh"	37	0.281183284
"AssetCur"	17	0.260184307
"LiabN"	22	0.250542042
"EBIT"	58	0.235368143
"NetProf %"	62	0.229200787
"P/E"	41	0.22376519
"Invent"	15	0.211280118
"LtDebtN"	18	0.164321731
"Gross %"	60	0.146136151
"EBIDT"	57	0.137654075
"EBT"	59	0.129638854
"IncNet"	26	0.125207845
"Operat %"	61	0.11343609
"Cash"	11	0.112716155
"Div"	12	0.112368981
"EPS(D)"	9	0.105623823
"ROE"	64	0.100652529
"ROI"	65	0.088326741
"DebtC"	20	0.087069201
"ROCE"	48	0.086804569

Correlation analysis can be considered as the first step of factor analysis. The main task of factor analysis is to identify small amount of linear combinations of initial ratios, so called 'factors', which can with high exactness forecast the behavior of price. Correlation analysis gives the indications, which primary ratios can be considered as candidates to include them in factors.

Using the primary fundamental data it is possible to calculate valuation related ratios, which are not included into financial statements, but are important for investment decisions - Economic Value Added EVA, Shareholders Value Added SVA, Weighted Average Cost of Capital WACC, Return on Invested Capital ROIC, Free Cash Flow FCF, Altman Z-factor, Ohlson's O-Score and others by the following way:

EVA	=IncNet(4Q) – (WACC x (Assets-LiabC)
EVAGr	=Growth EVA
WACCGr	=Growth WACC
EVA/IncNet	=EVA/IncNet(4Q)
EVA/Equity	=EVA/Equity
EVA/LiabCur	=EVA/LiabCur
GNP	Gross National Product Price index (Average for the last 5 years) = 110
O-Score	= -1.32 – 0.407 x Log(Assets/GNP) + 6.03 x (Liab/Assets) – 1.43 x ((AssetCur-LiabC)/Assets)) + 0.0757 x (LiabC/AssetCur) – 1.72 x X
Z-Score	=0.012 x ((AssetCur-LiabC)/Assets)) + 0.014 x (RetEarn/Assets) + 0.033(EBIT/Assets) + 0,006 x (Cap/Liab) + 0,999 x (Sales(4Q)/Assets)
EarnYield	IncOper(4Q)/(Cap+ LtDebt+DebtC)
CF	=EBIT + Amort(4Q) – Taxes(4Q) (Cash Flow From Operating Activities = EBIT + Depreciation – Taxes)
CFROA	=CF/Asset(+4Q)

6. TECHNICAL DATA ANALYSIS

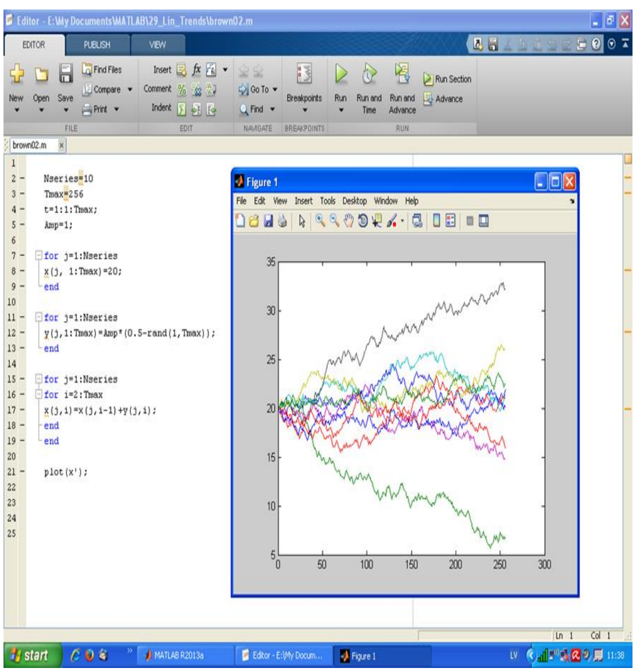
Starting the consideration of theoretical methods of technical analysis, it is necessary to underline, that they are much more complicated for understanding for students than methods of fundamental analysis.

The main theoretical method of fundamental analysis is the factor analysis and it is understandable by students relatively easy. Students of economics and business administration have good understanding of economic ratios, they understand relations between them and it is easy to explain them, how EVA /SVA (fair stock price) evaluation is related to stock price forecasting. If stock EVA is higher, than stock current market price, there are reasons to believe, that stock market price will grow up.

Situation with technical analysis is more complicated – it is not easy to explain, why relations between economic parameters, which were observed in past, will hold in future. From fundamental analysis point of view financial time series P(t) consist of regular, chaotic and stochastic components

$$P(t) = \alpha R(t) + \beta H(t) + \gamma S(t), \quad \alpha + \beta + \gamma = 1, \qquad (2)$$

where regular part R(t) is determined by superposition of trends and different scale periodic processes (e.g. economic cycles or seasonal agriculture price oscillations), chaotic part H(t) is determined by properties of economy as chaotic dynamical system, stochastic part S(t) is determined by random factors. Depending on weights α , β, γ values time series can be or completely predictable (α=1), or completely unpredictable (γ = 1), or partly predictable.



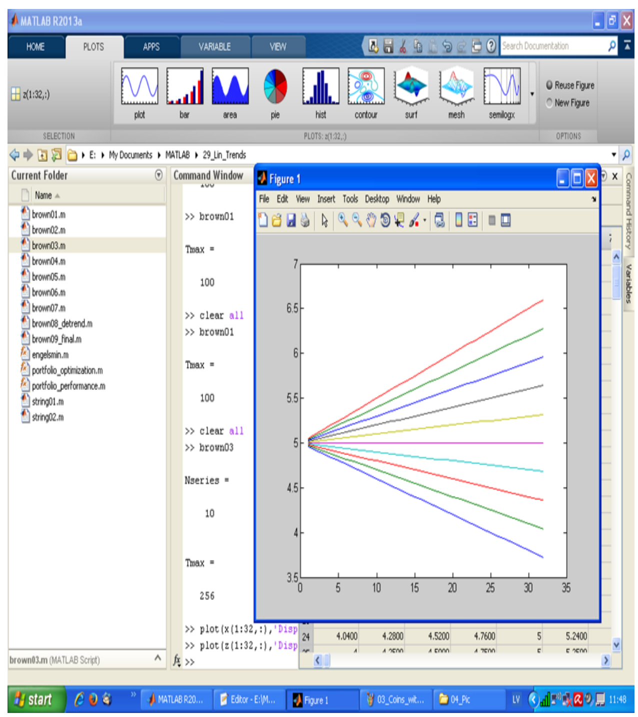
Pic. 2. Gaussian random process.

Typical completely unpredictable process is coin toss. If the coin felt on avers 100 times in a row, the probability to fell on avers next time is 0.5. The previous history is not influencing the result of next attempt – it means, that there is no sense to analyse the previous history trying to forecast the result of the next coin toss. The question whether there is a sense to analyse the history of stock prise to forecast future prices arise here. This is fundamental question of technical analysis and to answer it, it is necessary to make several computational experiments.

It is necessary to make remark on mathematical modelling here. Mathematical modelling usually is not included in educational programmes of economists and managers. As result they do not understand, that modelling is the third main method to receive new knowledge in addition to theory and experiment, they do not know how it is possible to understand something new using mathematical modelling method and how mathematical modelling is related with reality. Example, which is considered below, for many students was the first case when they received answer for complicated question which is related to financial reality using mathematical modelling.

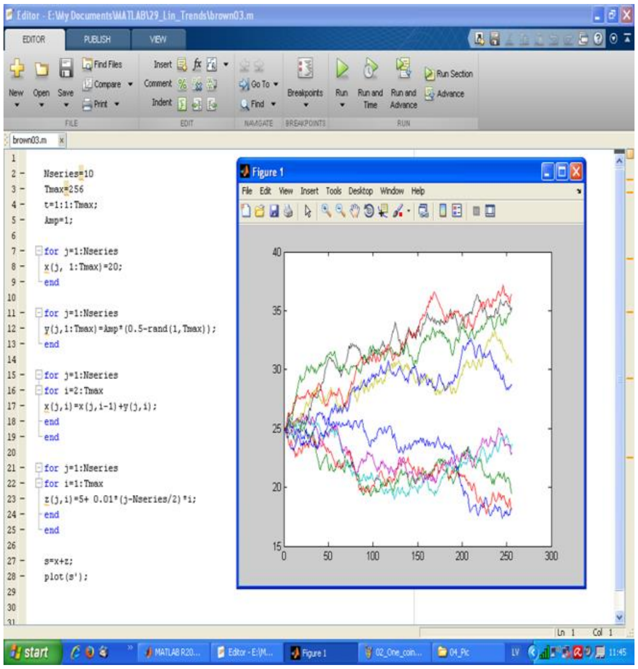
At first let us construct pure Gaussian random processes. Pic. 2 shows the set A of pure Gaussian random processes that are obtained by Matlab randon number generator rand(), adding 250 randomly given numbers from interval [-1,1] to initial value 20.

Pic. 3 shows non-random processes – the set of linear trends B, which include as rising so and falling linear trends.



Pic. 3. Linear trends

Pic. 4. shows set of random processes C, representing sum of pure Gaussian processes A with linear trends B, where randomly given 250 numbers are added to linear trends.



Pic. 4. Gaussian processes and linear trends superposition.

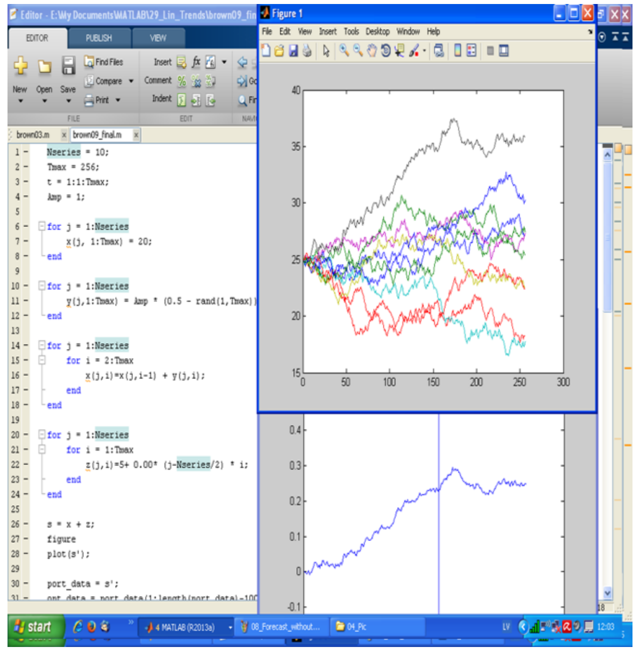
Looking on the one given random process it is impossible to determine to which group A or group C it belongs. However, if there is set of many random processes from the same group A or C, the classification of belonging to certain group A or C is possible. The main idea of such classification is based on the specific contribution of linear trends in portfolios, created from above mentioned random processes.

Let us divide all 250 days time interval, on which time series are given, on two parts – first 150 days we will call as interval of optimization, last 100 days we will call as interval of testing. Let us create Markowitz portfolio A from pure Gauss random processes of group A using optimization interval 150 days. The fundamental question is whether this portfolio A, which certainly grows on optimization interval, grows on testing interval also? After some reflection, it becomes clear, that the correct answer is "no" – for pure Gauss random process the number returned by random number generator does not depend on previous history. If pure Gauss random process grows on interval of optimization, there are no reasons why it should grow later on interval of optimization also. It is clear that situation remains the same for portfolio from A group random processes that are weighted sums of pure Gauss processes.

It is necessary to underline that for Markowitz portfolios C, which are created from processes from group C that are the sum of pure Gauss processes with linear trend, situation is completely different. If portfolio C from random processes from C group grows on the interval of optimization, it grows on the interval of testing also. The reason is simple – sum of pure Gauss process with growing trend has larger probability to be included in Markowitz portfolio than – sum of pure Gauss process with decreasing trend. But if such process is included in portfolio, linear trend "works" not on optimization interval only but on interval of testing also.

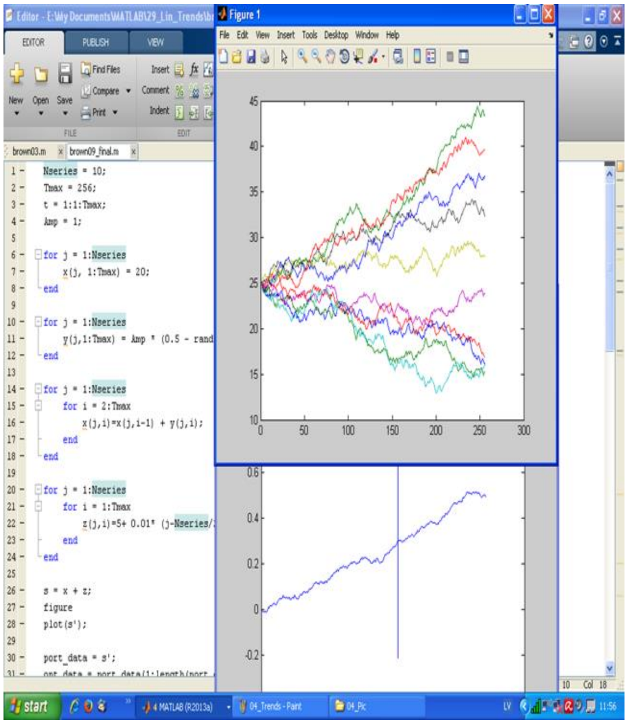
Now let us consider results of Markowitz portfolios A of processes from group A and C of processes from group C modelling on interval of optimization and interval of testing.

Pic. 5. shows typical behaviour of portfolio A that is created from pure Gaussian random processes and we can see that portfolio grows on optimization interval portfolio but is no longer growing on interval of testing. The growth of some stocks in portfolio is statistically compensated by decrease of other stocks and portfolio price can change only because of the fluctuations.



Pic. 5. Typical behaviour of portfolio A which is created from pure Gaussian random processes - portfolio is not growing on optimization interval.

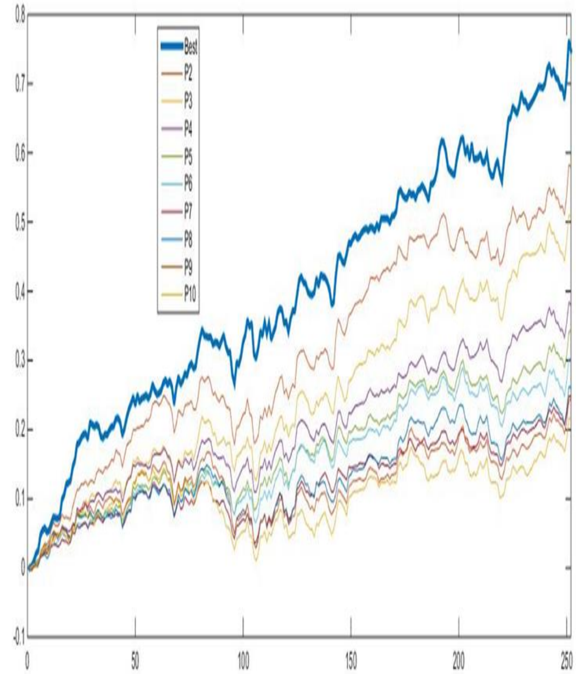
Pic.6. shows typical behaviour of portfolio C thatis created from random processes of group C. We see that situation with portfolio C is completely different from situation with portfolio A. If portfolio C was growing in optimization period, it will grow on testing period also. Reason of such difference was already described – growing linear trend that is included in the random processes of group C, increases the probability of selecting such process in the portfolio but falling linear trend decreases such probability. We see that if random process that is included in portfolio has linear growing trend in the period of optimization then it has the same growing trend in testing period. Linear growing tendsthat are included in portfolio from C group random processes also remains on the testing period and that is why if portfolio is growing in optimization period it will also grow in testing period.



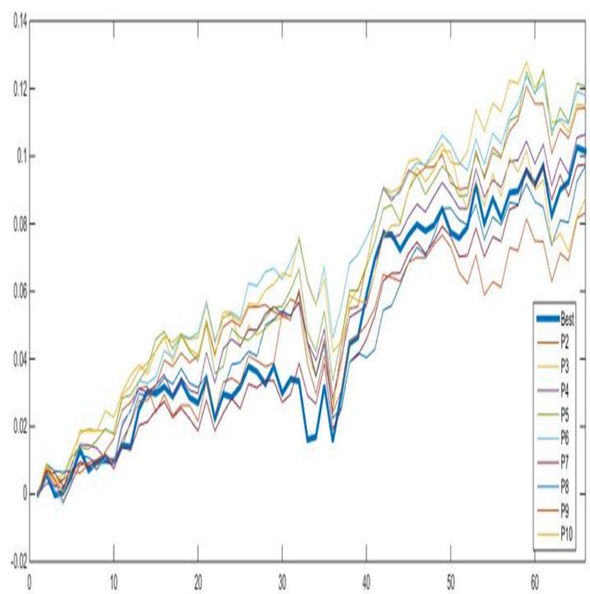
Pic. 6. Typical behaviour of portfolio from group C random processes (sum of Gaussian random processes and linear trends) - portfolio growth remains outside optimization interval.

Properties of portfolios that are created from A and C group random processes, can be tested very easy and it easy to show that C portfolio that grows on interval of optimization also grows on interval of testing. The question is what happens with portfolio from real stocks? It will be similar to portfolio created from random processes of group A or to portfolio created from random processes of group C? By the other words, whether the growth of portfolio from real stocks on testing period will be continued on optimization period? This question can be considered as a part of fundamental problem of investment theory – whether it is possible to forecast future behaviour of stock portfolio using data about this portfolio behaviour in the past?

In our case it is possible to show that the answer is "yes" - the portfolio from real stocks behaves in the same way as stocks of group C. Pic.7 shows behaviour of 10 real portfolios on the one-year period of optimization. Portfolios were sequentially created as Markowitz portfolios from the stocks of S&P500 index as follows. At first, the best Markowitz portfolio from all stocks of the index S&P 500 was created. After that, those stocks that were included in the best portfolio were excluded from the list of all stocks of index S&P 500 and another portfolio was created from the rest of stocks. After that, stocks from the second portfolio were also excluded from the list and the third portfolio was built from the rest of stocks. This procedure was repeated ten times and ten Markowitz portfolios were sequentially received from initial list of stocks. Quality of portfolios decreased in each subsequent step because each time the best stocks were excluded from the initial stock list.



Pic. 7. The behaviour of 10 portfolios on the one-year interval of optimization. Markowitz portfolios are sequentially created from the stocks of S&P500 index.



Pic.8. . Behaviour of ten portfolios in testing period. Portfolios are created from the stocks of S&P500 index.

Pic.8. shows behaviour of the same 10 portfolios on two month testing period. We can see that portfolios keep steady growth trend also outside optimization period, that is, they behave not like portfolios from pure Gaussian random processes of the group A, but like portfolios from sum of Gaussian random processes and linear trends of the group C. We underline the fact that we found the effect of the growth trend keeping outside the interval of optimization for portfolios that are composed from real stocks, which means, that it is possible to forecast real portfolios behavior.

Technical data analysis supposes the technical indicators use for prices forecasting. Matlab Financial Toolbox contains the following set of technical analysis indicators:

N	Function	Type
1	adosc	Accumulation/distribution oscillator
2	chaikosc	Chaikin oscillator
3	macd	Moving average conv/divergence
4	stochast	Stochastic oscillator
5	tsaccel	Acceleration
6	tsmom	Momentum
7	chaikvol	Chaikin volatility
8	fpctkd	Fast stochastic
9	spctkd	Slow stochastic
10	willpctr	Williams %R indicator
11	negvolidx	Negative volume index
12	posvolidx	Positive volume index
13	rsindex	Relative strength index
14	bollinger	Bollinger band
15	onbalvol	On balance volume
16	prcroc	Price rate of change
17	pvtrend	Price-volume trend
18	typproce	Typical price
19	volroc	Volume rate of change
20	wclose	Weighted close

This is enough to create the technical analysis based trading system and implement it to investment portfolio.

7. STOCKS SELECTION

The procedure of optimal stocks portfolio creation uses as fundamental so and technical analysis. There are approaches in the investment theory which are based on technical analysis only (Markowitz theory) or fundamental analysis only (fundamental ratios filtering) but in real practical investments they are not popular. Usually portfolio creation procedure consists of two parts – stocks selection, when stocks are selected according to fundamental financial ratios, and stocks weight factors in optimal portfolio determination, when stocks proportions are calculated using price time series. In our information system the following methods of stock selection are realized.

The first method of stocks selection is the boundary filtering. In accordance with investment strategy investor selects most significant fundamental ratios and assigns lower and higher boundary values for them. This selection can happen approximately in the following way. "I believe to large companies only, so the company Capitalization should be more than 1B. Company should have positive returns, so ROI, ROA, ROE should be over zero. In the case of price downshift I should be able to sell stocks back, so liguidity should be more than 10M per day during last year. I do not believe in companies with too high future income expectations, so P/E should be less than 70". After such selection is done it is easy to write Matlab "if" operator in the form if {(Capitalization > 1B) & (ROI>0) & (ROA>0)&(ROE>0)&(PE<70)} and select tickers satisfying to all restrictions. It is useful to compare received lists of tickers with results of available free of charge stocks screeners. We use finviz.com screener for such comparisons.

The second method for stocks selection is the rating system method, when ticker i receives the total rating as weighted sum

$$R_i = \sum_{j=1}^{j=n} r_{ij} F_j \qquad (3)$$

for j fundamental parameters F values. This approach is more flexible than previous, because company can compensate weak sides by other strong sides. E.g. company with capitalization 999 M would fail in boundary filtering with condition over 1B, but may pass selection by rating. It is interesting to attract attention of students that it is impossible to compare rating systems results with screeners' results – screeners, at least available free of charge, are not able to calculate ratings. Here we see the advantage of flexible modular information system comparing with screener. It is necessary to underline, that rating systems are almost arbitrary, there are no restrictions for rating systems ratios selection. In this sense rating systems are similar to boundary filtering, where used ratios can be selected according to investor preferences only.

It is possible to study the stocks rating parameters distributions for certain rating system. Let us consider for the example the rating system from the server of financial service company www.readyratios.com/features/full_report.html.

This system calculates the Financial Rating of Financial Condition FRFC by the following way

FRFC=0.6*F_Pos + 0.4*F_Perf, (4)

where financial position F_pos is weighted sum of financial position ratios

F_Pos=0.3*Debt_ratio +0.15*Non_curr_assets/Net_worth +0.2*Curr_Ratio+ 0.2*Quick_ratio+0.15*Cash_ratio (5)

and financial performance F_Perf is weighted sum of financial performance ratios

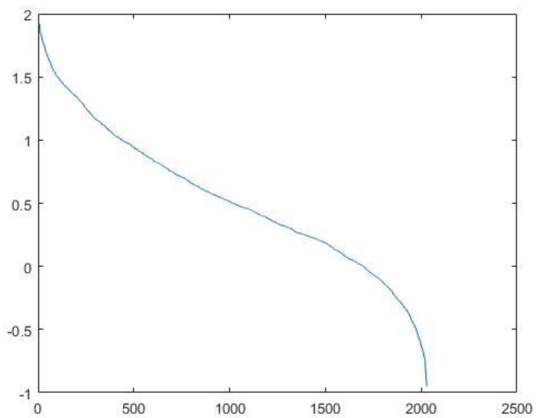
F_Perf=0.5*ROE + 0.3*ROA + 0.2*Sales_growth (6)

All ratios in (4) and (5) are scored in integer values form -2 (very bad) no +2 (very good). The financial condition scale for FRFC (Financial Rating of Financial Condition) looks as follows:

From	To	Sign	Qualitative assessment
2	1.6	AAA	Excellent
1.6	1.2	AA	Very good
1.2	0.8	A	Good
0.8	0.4	BBB	Positive
0.4	0	BB	Normal
0	-0.4	B	Satisfactory

-0.4	-0.8	CCC	Unsatisfactory
-0.8	-1.2	CC	Adverse
-1.2	-1.6	C	Bad
-1.6	-2	D	Critical

The FRFC distribution for US Russel 2000 companies for time interval 2012 – 2017 is presented at Pic.9



Pic. 9. FRFC distribution of US stock companies 2012/2017

The third method for stock selection is the use of certain valuation system. From computational point of view this method is similar to the previous, because valuation systems also calculate ratios, which can be interpreted as some sort of ratings. The difference between before considered rating systems and valuation systems is that rating systems use the historical data only, but valuation systems are forecasting based and should use very certain assets management, profit, growth ratios. Valuation systems are based not on the investor preferences only, but on certain theoretical base. The main idea of valuation is to compare the market value of stock with so-called fair value, which can be calculated discounting future cash flows and company terminal value to current time moment. The difference between stock fair value and current market value is the subject of investors' special interest.

8. PORTFOLIO OPTIMIZATION

After the stocks selection it is possible to create the optimal portfolio. From the methodological point of view, it is convenient to divide the optimal portfolio creation task on three stages. The first stage is the creation of Markowitz portfolio. Markowitz theory, often called as Modern Portfolio Theory (MPT), was suggested in 1952 and at present time is the classical part of investment theory.
The main idea of Markowitz theory is to create the portfolio with the best return/risk ratio. Portfolio return R is the ratio
R= (P_{end} – P_{begin})/ P_{begin} , where P_{begin} and P_{end} are portfolio prices at the beginning and at the end of time interval. Portfolio risk is the standard deviation σ of price from average value. If x_i and x_k are weights of tickers i and k in portfolio, which contains M stocks the σ^2 can be found by formula

$$\sigma_P^2 = \sum_{j=1}^{M} x_j^2 \sigma_j^2 + \sum_{j=1}^{M} \sum_{\substack{k=1 \\ k \neq j}}^{M} x_j \, x_k \sigma_{jk} .$$

where σ_{jk} is the prices of tickers j and k covariation matrix. The task of risk square minimization at given return

$$\sigma_P^2 \left(x_1, x_2, \ldots, x_M \right) \to \min$$

leads to conditional minimum task which can be solved using Lagrange uncertain coefficients method. Lagrange function looks as

$$L(x_1, \ldots, x_M; \lambda) \overset{def}{=} \sum_{j=1}^{M} x_j^2 \sigma_j^2 + \sum_{j=1}^{M} \sum_{\substack{k=1 \\ k \neq j}}^{M} x_j \, x_k \sigma_{jk} + \lambda \cdot \left(\sum_{j=1}^{M} x_j - 1 \right).$$

If in addition to stocks we include in portfolio risk-free asset with weight x_F and return R_F, Lagrange function accepts the form

$$L(x_1, \ldots, x_m) = \sigma_P^2 (x_1, \ldots, x_m) +$$
$$+ \lambda_1 \cdot \left[x_F \cdot R_F + \sum_{j=1}^{M} x_j \cdot \bar{R}_j - R_* \right] + \lambda_2 \cdot \left[x_F + \sum_{j=1}^{M} x_j - 1 \right],$$

and appropriate system of equation for weights x_i determination is the linear system that looks as

$$\begin{cases} 2 \sum\limits_{k=1}^{M} x_k \cdot \sigma_i \cdot \sigma_k \cdot \rho_{ik} + \lambda_1 \cdot \bar{R}_i + \lambda_2 = 0, \qquad i = 1, \ldots, M; \\ \lambda_1 \cdot R_F + \lambda_2 = 0 \\ x_F \cdot R_F + \sum\limits_{k=1}^{M} x_i \cdot \bar{R}_i = R_* \\ x_F + \sum\limits_{k=1}^{M} x_i = 1 \end{cases}$$

Matlab Financial Toolbox contains standard library functions which give the possibility to create Markowitz portfolio, to draw the frontier line and to show on the frontier line the Sharpe point - portfolio with the best profit/risk ratio. At this stage of optimal portfolio creation everything is good understandable and clear for students. Problematic questions arise when we consider the model example with artificial stocks, one part of which are linear growing and other part are sinuses oscillating around constants. Markowitz portfolio constructed from such artificial stocks strange enough – one or two growing stocks will be included in this portfolio and other stocks will be selected from non-growing on long intervals sinuses. Nevertheless, from intuitional point of view it is clear, that portfolio constructed from one stock with fastest growth is better than Markowitz portfolio and the question how to improve Markowitz portfolio arises.
The second stage of optimal portfolio constructing starts form detailed Markowitz risk consideration. As result it becomes clear that the profit/risk ratio for all linear functions is the same constant, that Markowitz risk is rather volatility than possibility to lose invested capital, that there are possibilities to construct portfolios with better returns than Markowitz portfolio without "common sense" risk increasing. Here the idea of Markowitz risk substitution with better risk measure if often suggested by students and it is necessary to explain them why until now such attempts are not successful. The explanation is very simple. Markowitz risk is the standard deviation from average value. Really we minimize at the fixed profit the dispersion which is square of risk and is quadratic on stocks weights. To find minimum of quadratic function it is necessary to take derivative and equate it to zero. The derivative of quadratic function is linear function and equating it to zero we receive linear equation. For all functions other than quadratic derivatives will

not be linear functions and equating them to zero we will receive non-linear systems of equations, which are much more complicated for solutions, than linear.

Here the important hidden feature of Markowitz risk is revealed - the system of equations for this risk minimization for fixed profit gives the linear system of equation. It is possible to solve linear systems containing thousands of equations, but if we substitute linear forms with quadratic forms system immediately become very difficult for solution. The substitution of Markowitz risk with other risk measures gives non-linear systems of equations for portfolio optimizations. The second stage of portfolio optimization is the consideration of different risks other than Markowitz.

The third stage of portfolio optimization is the creation of portfolios by advanced methods. To receive better portfolios than Markowitz we consider the set of risk measures such as T-risk, S-risk and V-risk are related to probability and mathematical expectation to loose invested capital. Portfolios which optimize the profit to risk ratio for T-, V- and S-risks can be created and compared with portfolios received using other approaches.

9. PORTFOLIO TESTING AND COMPARING

For many years server finance.google.com allowed to create and test stocks portfolios free of charge. Unfortunately, at present time, such possibility does not exist and it is necessary or to use commercial services, or test portfolios using own developed software.

Portfolio testing is related with portfolio characteristics calculation and most important of them are profit, risk, maximal draw down. Portfolio should be balanced also - it should not contain stocks with weight more than previously fixed, usually 5, 10, 15 percent depending on portfolio type. Portfolio should be diversified – stocks from all industry sectors should be presented in approximately equal proportions. Portfolio should be stable – deviations from the regression line should not be large.

Portfolios comparison is one of the most complicated questions of investment theory and practice. From one side, it is clear, that everything is relative in investments and portfolio selection assumes the procedure of portfolio comparison with other portfolios. From the other side, criteria what is good and what is bad in such comparison can be very different depending on investor preferences, portfolio type (conservative, standard, aggressive), time. In our information system we solve the portfolio comparison problem by the following way.

At the beginning, for different portfolios created by different methods for given time interval, usually this is on year, we calculate the same standard set of parameters - profit, risk, profit/risk ratio, Maximal Draw Down MDD, stability and several others. After that, we sort portfolios after each parameter and evaluate the place of portfolio in the sorted row. After that, we sum places received by portfolio – that which is on the 1st place by all parameters receives the minimal score, that which is on the last – maximal score. Now we can compare different portfolios by scores – portfolio with less score is preferable than other.

Such simple approach gives possibilities to compare results of different methods of portfolio optimization. It is convenient to start the comparison of different portfolio creation methods from random portfolios consideration. Random number generator gives the random number N from given interval – this is the amount of stocks. From the list of stocks N tickers are randomly selected and capital is evenly distributed among them. We can receive thousands such random even portfolios and after that optimize them, creating from the same stocks Markowitz portfolios. Comparing optimized portfolios with even it is easy to evaluate the contribution of optimization into portfolio performance – Markowitz portfolios are 10-20% better than even. By the way, this is the indication for asset management companies that optimization can improve portfolio. It is known from practical experience that sometimes asset management companies due to different reasons use for investment even portfolios.

If possible to make the similar comparison for other methods of portfolio optimization – to compare Markowitz portfolios with portfolios, which are optimized by profit ratio to V-risk (mathematical expectation of loses) and S-risk (probability of loses). The result of such comparison is non-trivial – S-risk optimized portfolios have better returns than V-risk optimized. Reformulating this result it is possible to say that investors are more afraid of probability to lose capital than of mathematical expectation of loses. May be the reason of this lies in investors' psychology – the first and most important question for investor is not to lose the capital. The question “If loses happens, how large they will be?” is on the second place and less important than the first one.

A very interesting question related to different portfolios comparing is the question about not separate portfolios, but sets of portfolios comparing. Comparing sets of portfolios, it is possible to compare different methods of portfolio optimization. Each method has it's own optimization criteria and according to this criteria portfolios of other methods will be worse. But when all such portfolios are included in one list and evaluated according to above described “places based score”, optimization criteria of different methods are not important more and the position of certain portfolio among other portfolios we receive “places based score” as relative global portfolio quality criteria.

10. PORTFOLIO CORRECTIONS

For approximately 8 years the global markets were considered as stable growing. Behavior of the markets has changed at the end of January of 2018. At first, at January 19, 30-years USA bond price rise up, after 4 days the same with 10-years USA bond happened and after 4 days 10% correction of US markets started. This was the greatest market downshift since 2008 year crisis and at present time situation is not stabilized. The responsible approach to investment requires new approach to decision making and at first of all more deep analysis of current situation.

The very popular approach to stocks portfolios management for the 8-years period of market growth was the following. Each quarter stock companies present quarter reports, which are available in EDGAR. On the base of these reports, investors re-consider their investment portfolios, making corrections of two kinds. At first, new fundamental data of portfolio stocks are considered and in the case of deterioration of financial performance some stocks can be excluded form portfolio or substituted with other stocks. At second, due to changes in the portfolio composition it is necessary to recalculate stocks weights. Both corrections usually are large - in the case of even portfolio weights of remaining stocks are not changed at all, in optimized portfolios stocks weights changes rarely more than by 10%. The reason of this is that portfolios are optimized on time intervals of several years and one quarter contributions in changes are not significant.

This approach to stock portfolio corrections was good enough for approximately 8 last years, but at present time it certainly should be modified. The main improvement which should be done is related with the possibility of rapid market declines as it was between January, 26 and February 8 when S&P500 fall from 2872 to 2581 or about 10%. For such situations it is necessary to work out special rules of short-term portfolio corrections which are different from quarter corrections considered before.

There are several approaches for such short-term corrections rules formulation. In our system we use the Bollinger bands based approach, which is popular in such technical analysis based forms of trading as intraday FOREX and short-term futures trading. If portfolio price decries more than 1.2 σ from average value it is necessary to close this portfolio.

11. CONCLUSIONS

The functionality of information system created at the Ventspils University College for the study course "Stock market fundamental and technical analysis" support is considered. System can be used for many purposes.

At first, it can be used in study process as set of laboratory works to explain theoretical material and demonstrate different properties of stock companies. It can be as simple statistical properties, for example, the ROI, ROA, ROE and other ratios distributions, so and more complicated properties. For example, it is possible to study the efficiency of management of US stock companies. It is accepted in business administration that management works good if turnover of company grows faster than capital and profit grows faster than turnover. Using described information system it is possible to find such companies.

At second, describes information system can be used in research work. The simplest research works at Ventspils University College are course works, more complicated are bachelor, master and doctoral works. For research works of all levels there are themes which can be investigated using described information system.

At third, describes information system can be used in practical applications. Several former bachelor and master students use parts of this system in financial companies. Portfolios, created using described system, demonstrated good results comparing with assets management companies portfolios.

System can be developed in many directions. The nearest plans of system development are related with the online version with web interface creation, the implementation of system for financial health of companies evaluation and used algorithms optimization.

12. REFERENCES

[1] R. Debreceny, C. Felden, B. Ochocki, M. Piechocki, M. Piechocki, XBRL for Interactive Data: Engineering the Information Value Chain. Heidelberg, Springer, 2009.

[2] B. Kampgen, T.Weller, S. O'Riain, C.Weber, A.Harth, „Accepting the XBRL Challenge with Linked Data for Financial Data Integration", Institute AIFB, Karlsruhe Institute of Technology, Karlsruhe, Germany, 2014.

[3] B. Lev, S.R. Thiagarajan, Fundamental Information Analysis, Journal of Accounting Research, Vol. 31, 190-215, 1993.

[4] P. Fernandez, Company Valuation Methods. The most common errors in valuations, Working paper No. 449 of IESE Business Schol-University Navarra, 2002.

[5] E. Bolten, „Stock Market Cycles. A practical explanation.", Quorum Books, Westport, Connecticut – London, 2000.

[6] S. Chung, M. Rosenberg, J.F. Tomeo, Hedge Fund of Fund Allocations Using a Convergent and Divergent Strategy Approach, The Journal of Alternative Investments, Vol. 7, No. 1, pp. 44-53, 2004.

[7] T. Koller, M. Goedhart, Valuation: Measuring and Managing the Value of Companies, University Edition Fourth Edition, McKinsey&Company, 2010.

[8] J. Ou, S. Penmann, Financial statement analysis and the prediction of stock returns, Journal of Accounting and Economics 11, 295-330, 1989.

[9] D. Owen, R. Griffiths, Mapping the Markets. A guide to stockmarket analysis, Bloomberg press, 2006.

[10] H. M. Markowits, Portfolio Selection, Journal of Finance, vol. 7, No.1, pp. 71-91, 1952.

[11] B. Graham, Security Analysis. The classic 1934 edition, Mcgraw-Hill Book Company, Inc., New York – London, 1934, 2014.

[12] S. Hilkevics, New Information Technologies Use for Latvian Companies Financial Health Evaluation, Entrepreneurship and Sustainability Issues, 2017, vol. 5, No. 2.

[13] T. Robinson, H. van Greuning, E. Henry, M. A. Broihahn, International financial statement analysis. Hoboken, N.J., John Wiley & Sons, 2009.

[14] D. Nissim, S. H. Penman, Ratio Analysis and Equity Valuation: From Research to Practice. Review of Accounting Studies, vol.6 No.1, pp. 109-154. 2001.

[15] R. Kaplan, D. Norton. The Balanced Scorecard--Measures that drive performance. Harvard Business Review 70 (1):71-79, 1992.