THE APPLICATION OF SELF-ORGANIZING NEURAL NETWORKS IN FINANCIAL MARKET ANALYSIS

Giedrius Stankevicius
Kaunas University of Technology, Studentų 48-327, Kaunas, LT-3028, Lithuania
phone: 370-7-798886, e-mail: giedrius@ earthling.net

ABSTRACT

The problem of comparison of different companies is facing, when analyzing company's performance in stock exchange market. Due to many different financial ratios and parameters sometimes it is almost impossible to decide which company is a leader or not. One of the ways to solve this problem is the use of self-organizing (Kohonen's) neural networks. Using financial parameters as inputs, as an output we will have different groups of companies. Using the ranking, which is made before, results it is possible to determine which group consists of leading companies. By adding financial parameters of concrete company to the existing network, therefore, company will appear in one of earlier formed groups. Now it is possible to decide about mentioned company's price changing tendencies in the nearest future.

Key words: *self-organizing neural networks, clustering, stock market.*

1. Introduction

Due to the globalization of financial markets, expansion of the electronic trade and the growth of information about the market, the specialists of investment funds more frequently try to use artificial intelligence methods for the market analysis [2]. These methods are widely used in so-called intelligent process control and monitoring systems [5]. Works related with the use of neural networks, obscure sets methods and expert systems for financial analysis and formation of trade decisions, receive the greatest recognition and interest in financial markets. The possibilities of self-organizing networks for clustering shares of different companies and formation of "stock leaders" groups are analyzed in this work. Discussed methods are presenting as one of the possible recommendations for the investing companies.

Stock analysts more frequently try to combine the methods of technical and financial analysis lately. The growth of quantity of the parameters characterizing the company's shares and the information that is necessary to work up is enormous in this case. Some methods that are able to work fast with the information and are able to select the most decisive parameters when we have in mind the tendencies of the share price change are proposed in this study.

2. Factors that influence the stock market

Many factors decide the share price change in the market. One of the main problems of stock market analysis is to establish the relations between these factors, the share price and the tendencies of share price change. This task is very complicated because of complexity of the relations between factors.

Before the explanation of these relations, it is necessary to overview those factors that, according the opinion of stock market analysts, have the most influence on share price change. The factors can be divided in three groups: objective factors, speculative factors and subjective factors. Objective factors can be divided into micro and macro level factors. [4]

Micro factors have an effect on the concrete company's share price. Company's financial state, the size of the company, net profit margin, the perspectives of the industry sector, to which company belongs, are known as micro factors. Besides above-mentioned factors, very specific factors of company's policy have an influence the share price changes.

Macro factors have an effect on the group of the companies or the whole market. Some of the macro factors are: the stability of economical system, the level of saving and the size of State debt, conjuncture of gold, real estate and commodities, economical growth rates, inflation, international money flow rates, the state of currency system, etc.

Expectations are speculative factor. Sometimes expectations have more influence on the market than objective factors. Then the most important thing is the possibilities to win because of differences of share price rate. The dividends and interest rates are not so important in this case.

The significance of subjective factors in the stock markets is very big. By their nature, they can occur because of technical stock market analysis, prediction methods and because of the opinion of

financial analysts. When we are talking about financial market analysis, it is necessary to mention, that analysts can different interpret the same fact.

It is difficult to estimate all mentioned parameters in quantities. Sometimes it is impossible. Thus, it is impossible to decide how these factors relate. Technical and fundamental analysis methods and parameters with clear meanings are used for the financial market analysis.

Some certain premises should be taken into account, when using technical analysis methods. It is accepted that price changing tendencies could be established with the use of prehistoric data of stock parameters and factors [3]. There are some of the parameters, which are used for the technical stock analysis:

1) shares outstanding;
2) opening price of share;
3) closing or last bid price of share;
4) highest price of share during the trading day;
5) lowest price of share during the trading day;
6) average daily trading volume;
7) the rate of different stock indexes, etc.

The detailed analysis of the company activities and its financial reports is carrying out, when using fundamental stock analysis. Stock market analysts turn their attention at these parameters [1]:

1) earning per share growth;
2) return on assets and equity;
3) debt to assets and equity;
4) net profit margin, etc.

As it was mentioned earlier, stock analysts more frequently try to combine the methods of technical and financial analysis lately. The growth of quantity of the parameters characterizing the company's shares and the information that is necessary to work up is enormous in this case. Some methods that are able to work fast with the information and are able to select the most decisive parameters, when we have in mind the tendencies of the share price change, are proposed in this study.

3 The application of neural networks for the market analysis

The use of neural networks is based on the possibilities of neural networks to estimate the relations between different market factors during the training. The merit there is that relations between different factors are not fixed a priori, but are estimated during the training with the help of experimental data. Thus their outputs are safe from so-called 'human factor', when we obtain the desirable result, but not the result which shows what is hiding inside the data. The attempt to find the relations between the share price and different market factors during the network training is made. The technical and financial data about the market's state and the company's financial state is used as the inputs for the neural network in this case. When sufficient quantity of data is presented for the network training, it is possible to identify complex non-linear dependencies between analyzing variables and share price. It is also possible to find the tendencies of share price change. Unfortunately, different subjective factors take strong effect on the stock market and neural network is incapable to estimate them. Thus, functional dependencies, which are identified after the training of network, should be estimated very carefully. The reliability of these dependencies drastically depends on the quantity and the quality of owned data.

3. Self-organizing neural networks. Basics and training.

The major function of self-organizing networks is to automatically classify input patterns into a number of disjoint clusters. The patterns located in the same cluster have similar features. The self-organizing networks is formed in terms of unsupervised learning, i.e. learning without a teacher, for instance winner-take-all competitive learning. Here we introduce the algorithm of competitive learning self-organizing networks. In a self-organizing network, a vector quantizer can be performed by adjusting weights from N input nodes to M output nodes. When the input patterns have been presented sequentially to the network without specifying the desired output, the input patterns can be automatically classified into M clusters. The structure of self-organizing neural networks and the geometrical explanation of competitive learning are schematically illustrated in **Figures 1** and **2**.

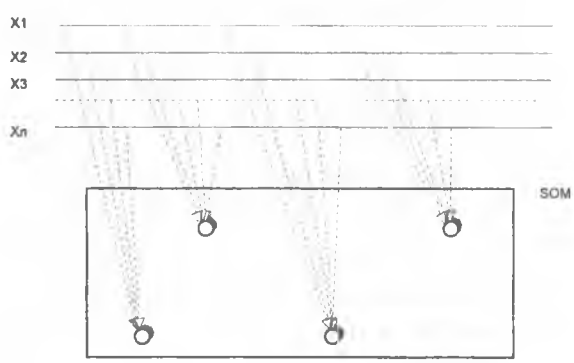

Figure 1. Topology of Kohonen self-organizing network

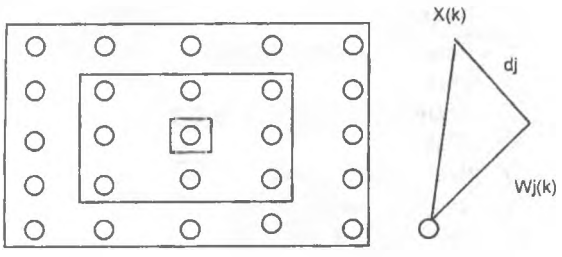

Figure 2. Geometrical illustration of competitive learning

The detailed learning algorithm can be summarized as follows:

Step 1: Randomly initialize small valued weights

$$W_{ij}(0),\ i=1,\ N;\ j=1,M.$$

Step 2: Present input vector:

$$x_i,\ i=1,N.$$

Step 3: Calculate the distance between the input vector and the weight vector for all individual output nodes:

$$d_j = \sum_{i=1}^{N} (x_i(k) - W_{ij}(k))^2 \qquad (1)$$

Where $x_i(k)$ is the input to the node i at time k, and $W_{ij}(k)$ is the weight from input node i to output node j at time k.

Step 4: Select the most active output node j^*, or the so-called 'winner' which has the least distance, i.e.

$$d_{min} = \min\{d_j, j=1,M\} \qquad (2)$$

If $d_j=d_{min}$ then $j=j^*$ and $y_j^*=1$, otherwise $y_j=0$ (j is not equal j^*).

Step 5: Upgrade the weights for the 'winner' node

$$W_{ij}(k+1)=W_{ij}(k) + g(k)\, y_i\, (x_i-W_{ij}(k)) \qquad (3)$$

Where $g(k)$ denotes learning rate and is defined as a time decreasing function within the range (0,1).

Step 6: Repeat by going to Step 2.

From equation (2), we can see that eventually the weights are upgraded only for the winner node j^*. However, in practice, the weights can also be upgraded only for the winner node j^*, but also for all nodes in the neighborhood of the winner. The size of the neighborhood $NE_j(k)$ can be predefined and can start large and slowly decrease in size with time. The weights upgrading may follow a modified version:

$$W_{ij}(k+1)=W_{ij}(k) + g(k)\, (x_i-W_{ij}(k)) \qquad (4)$$

for all j which are located in the neighborhood $NE_j(k)$.

There are many different software packages for the realization of self-organizing networks.

In our study, we will use a demo version of **Viscovery® SOMine** software (http://www.eudaptics.com/index.html).

4. Preparation of the data

For the testing of possibilities of self-organizing neural networks for financial market analysis, the data from USA stock exchanges was used. The first step was the screening of the companies. We used **StockQuest®**, software for this operation. This convenient software is available through the Internet. The user has a possibility to build up a portfolio from about 50 different factors. The screening is implementing, when certain factors were chosen. The first problem is to pick up empirically 12-15 factors, by recommendations of financial market analysts, and use these factors to build up a portfolio, which consists of potential to buy shares. Second problem is to rank these selected shares. To solve this problem certain weights were given to the factors. Weights were given according the opinion of financial analysts [1]. Third, and the main problem, is to divide selected shares in some groups (leaders, losers) with the use of self-organizing neural networks.

5. Clustering course and the results.

Because of limited size of the article, the solving of the first and the second problems are overviewed shortly. The realization of the third problem is analyzed more extensively. As it was mentioned above, at first, 15 factors and their meanings were chosen according to the opinion of the financial analysts. Using the **StockQuest** software, the selection of companies was made. The portfolio consisted of 30 companies. Then certain meanings of weights were empirically given to the factors, which characterized the companies. Right after this, the ranking of the companies was made - by estimation of all weights, company was assigned to its place in the general listing. Companies situated from leaders to the losers. During the next step, it was necessary to make sure, that companies can be divided into clusters corresponding to the general listing. We used **"Viscovery SOMine"** software for the clustering operation. There are some restrictions in the demo version of the software. The amount of the factors available to analyze is nine. Because of this reason, it was impossible to make clustering operation with the whole amount of factors at once.

The parameters were changed one with each other. This restriction has merit - after detailed analysis it is possible to decide which factors are decisive when dividing the companies in the groups. A few factors were declined to make easier the changing the factors one with each other. It was factors with absolute meanings, because they depend on the size of the company, the quantity of the workers in the company, etc. The parameters with relative meanings were left for the further analysis and clustering. After the first attempt of clustering, it was impossible to determine any group of companies, neither leaders nor losers (according the ranking list) (**Fig. 3**). The numbers on the figure mean the lace of the company in the ranking list.

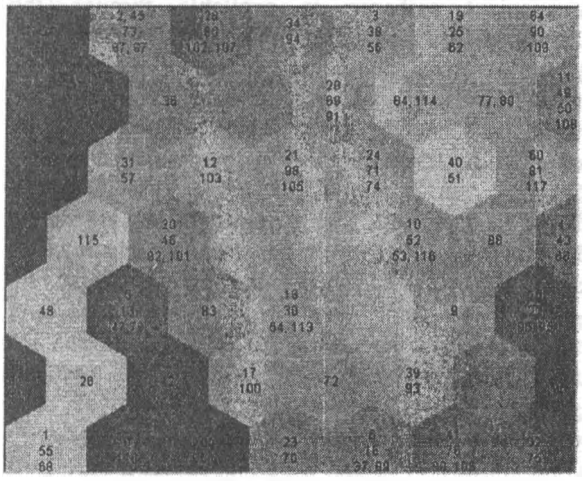

Figure 3. Clustering result after the first attempt

Then clustering vas made with different combinations of the factors. Thus, the influence of different parameters was analyzed. The influence of separate factors was analyzed too (there is the special option in the software). After the detailed analysis it became clear, which factors have the most effect on the formation of groups (**Table no. 1**)

Table 1. Recommended set of factors for the screening and clustering of the companies

No.	Factor	Meaning
1	Earning per share growth rate, 3 Years (%)	>25
2	52 week price percent change (%)	>25
3	Current price of share, ($)	>10
4	Revenue growth rate, 3 years (%)	>25
5	Return on average common equity, TTM (%)	>15
6	Long term debt to total equity, quarterly	<1
7	Insider ownership percent (%)	>20
8	Institutional percent owned, (%)	>5
9	Net profit margin, TTM (%)	>5
10	Price to earnings ratio, excluding extraordinary items, TTM	<100

After the clustering operation with the factors from the **Table 1**, the results showed that few groups of the companies were formed (**Fig. 4**). The group of the losers appeared most clearly. Other companies scattered chaotically in the upper left and the lower right corners. These companies were not shown for the clarity of the picture.

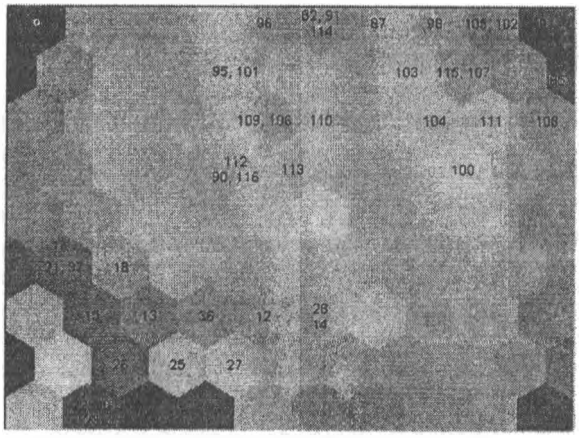

Figure 4. Clustering result with the selected set of factors

Finally, the result was not satisfying enough. The groups didn't appear clearly, some losers were in the same clusters with the leaders. The problem is that the ranking weights were selected subjectively. Thus, the ranking list is also subjective. The results of ranking and clustering varied. Adopting the weights would have an effect on the ranking results, but it can lead to the non-objective results.

By adding financial parameters of concrete company to the existing network, therefore, company will appear in one of earlier formed groups. Now it is possible to decide about mentioned company's price changing tendencies in the nearest future.

The following algorithm is the summarized clustering process algorithm:

1) Different companies are selected by the recommendations of financial market analysts. Recommended set of factors for selection (screening) is shown on the **Table 1**.

2) The ranking list of selected companies should be built. The weights for the ranking list are selected according the opinion of financial analysts.
3) All selected companies should be clustered.
4) By comparing the ranking list and the clustering results, groups of leader and loser companies should be determined.
5) The data about the company of our interest should be selected. The parameters of the data should be the same as for the companies selected earlier.
6) This data should be added to already trained self-organizing neural network. The company should appear in one of the earlier formed groups. Now it is possible to decide about mentioned company's price changing tendencies in the nearest future.

6.Conclusions

Following conclusions was made according the results of the study:

- Self-organizing neural networks can be used as the powerful tool for the financial market analysis.
- Selected parameters are usable (with some exceptions) for the clustering of the companies.
- The result of the clustering is the formed groups of leading and losing companies.
- Clustering can be used for creation of the decision support systems for the financial market analysis.

REFERENCES

Allrich, T. (1995). *The on-line investor. How to find the best stocks using your computer*, 240 p. St. Martin's Griffin, New York.

Marshall, J., Ed. (1997). *Conference on Computational Intelligence for Financial Engineering (CIFEr)*, 307p., Crowne Plaza Manhattan, New York.

Perk, R. (1990). *Professionelle Aktienanalyse fur jedermann*, 135 p. Verlag C.H.Beck, Munchen.

Rasteniene, A. (1998). *Vertybinių popierių rinka*, 64p., Lietuvos informacijos institutas, Vilnius.

Tsoukalas, L., Uhrig, R. (1997). *Fuzzy and neural approaches in engineering*, 585 p., John Wiley & Sons, New York.