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Integrating dynamic fuzzy C-means, data envelopment analysis and artificial neural network to online prediction performance of companies in stock exchange

Mustafa Jahangoshai Rezaee *, Mehrdad Jozmaleki, Mahsa Valipour

Faculty of Industrial Engineering, Urmia University of Technology, Urmia, Iran

HIGHLIGHTS

- Proposing an approach for online prediction performance of units.
- Development of fuzzy c-means to be dynamic behavior.
- Integrating DFCM, DEA and ANN.
- Applying proposed approach in a real case study on stock exchange market.
- Evaluating and predicting companies using financial ratios in six years.

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ABSTRACT

One of the main features to invest in stock exchange companies is their financial performance. On the other hand, conventional evaluation methods such as data envelopment analysis are not only a retrospective process, but are also a process, which are incomplete and ineffective approaches to evaluate the companies in the future. To remove this problem, it is required to plan an expert system for evaluating organizations when the online data are received from stock exchange market. This paper deals with an approach for predicting the online financial performance of companies when data are received in different time's intervals. The proposed approach is based on integrating fuzzy C-means (FCM), data envelopment analysis (DEA) and artificial neural network (ANN). The classical FCM method is unable to update the number of clusters and their members when the data are changed or the new data are received. Hence, this method is developed in order to make dynamic features for the number of clusters and clusters members in classical FCM. Then, DEA is used to evaluate DMUs by using financial ratios to provide targets in neural network. Finally, the designed network is trained and prepared for predicting companies' future performance. The data on Tehran Stock Market companies for six consecutive years (2007–2012) are used to show the abilities of the proposed approach.

1. Introduction

Investment is an important factor for development in the current century. In this regard, the most important investment way that can lead to the various industries and economic activities, is Stock Exchange Market. Furthermore, the management

* Corresponding author.
E-mail address: m.jahangoshai@uut.ac.ir (M. Jahangoshai Rezaee).

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of transferring the risk and distributing it, information transparency, price discovery, and creation of competitive market are the other basic functions of Stock Exchange. The importance of stock exchange markets in developed countries is very much so that nowadays it is one of the most important indicators of economic growth of these countries. Because of the increasing of variables affecting decision making, nowadays, managers, investors, stakeholders prefer to have a mechanism that can help them in decision-making. For this reason, the new methods are used by which the prediction of the estimations is closer to reality and has the low-level errors. Therefore, if the future trend of the stock market may be predicted more accurately by appropriate methods, investors can maximize returns from the investments. Since the mid-70s, many endeavors for increasing capabilities of stock pieces, returns, and efficiencies using mathematical methods, econometrics, and intelligent systems have been begun and many researches have been done on stock price and index in several developed countries such as Britain, the United States, Canada, Germany, and Japan. To be shown existence or lacks of stock price information in certain structure and violated the assumption of stochastic steps.

Forecasting and predicting methods used so far have been divided into two general categories, including classical and modern methods. Classical methods include econometrics-based approaches, statistical inferences, and traditional mathematical programming. In recent years, many advances in predicting stock prices in different countries using the soft computing algorithms and artificial intelligence emerged. Various algorithms and methods such as neural networks, meta-heuristic algorithms, and fuzzy inference are in this domain that they have achieved successful results in solving complex problems. Schwartz and Whitcomb [1] have done one of the first studies on stock market prediction using neural network. Using IBM daily prices, they showed that the neural networks are able to identify non-linear patterns in time series and the unknown rules on asset price and stock price changes.

Afterwards, using neural networks have been extended in the financial sphere. Chiang et al. [2] used a back propagation network for predicting net asset price of investment companies at the end of the year. Their network results with the results obtained from traditional econometric methods were compared. They found neural networks are significantly more effective than regression-based methods when the number of data is low. Leung et al. [3] used General Regression Neural Network (GRNN) for forecasting UK exchange rate. They compared GRNN with other forecasting methods including multi-layer feed-forward network (MLFN), multivariate transfer function, and random walk models. The results showed that GRNN has a higher degree of forecasting accuracy and performs statistically better results than other mentioned methods.

Also, Chen and Leung [4] proposed a forecasting approach that combines the strengths of neural network and multivariate time series models. In the proposed approach, first, forecasting exchange rate of UK, USA, and Japan was done by time series and then GRNN was used to correct the forecasting errors. Santos et al. [5] examined forecasting accuracy of exchange rate in Brazil using different approaches. For this purpose, they applied the intelligent systems such as multilayer perceptron and radial basis function neural networks and the Takagi–Sugeno fuzzy system versus the traditional methods such as auto regressive moving average (ARMA) and ARMA-generalized auto regressive conditional heteroskedasticity (ARMA-GARCH) linear models. They found the intelligent-based methods are able to provide more accurate results than the traditional methods. Carriero et al. [6] forecast 33 exchange rates with a large Bayesian Vector Auto Regression using multivariate time series models. Other works were done by Chortareas et al. [7] for forecasting exchange rate volatility using high-frequency data, Sermpinis et al. [8] applying radial-basis functions neural network and particle swarm optimization to forecast foreign exchange rates, Sermpinis et al. [8] for forecasting and trading the EUR/USD exchange rate using the Psi Sigma Neural Network (PSI) and the Gene Expression algorithm, Yuan [9] using polynomial smooth support vector machine to forecast the movement direction of exchange rate. Afterwards, Korol [10] developed a forecasting exchange rate model with the use of fuzzy logic. The paper were evaluated the exchange rate at the time of welfare (2005–2007) and during the financial crisis (2009–2011). Sermpinis et al. [11] combined genetic algorithm and support vector regression (GA-SVR) to predict exchange rates. The authors have done their studies on three countries: USA, UK, and Japan since 1999–2012. The results indicate that the proposed method has high statistical accuracy and high performance. Pinčák and Bartoš [12] proposed an approach for analyzing and forecasting financial market and time series data. They showed their ideas were used about the portfolio selection problem of multi-string structure and the stability of the algorithm was demonstrated on transaction costs in long-term period. Kanjamapornkul et al. [13] investigated Thailand's stock market during the 2008 financial crisis. They redefined the behavior matrix for time series data using Pauli matrix and modified Wilson loop. This matrix was used to detect the 2008 financial market crash by using a degree of cohomology group of sphere over tensor field. Finally the analysis of financial tensor network was provided.

Oztekin et al. [14] applied three methods namely artificial neural network, adaptive neuro-fuzzy inference system, and support vector machine in order to predict daily stock return in a new business. They evaluated their method in stock market from 2004 to 2012. Rubio et al. [15] used weighted fuzzy time series (FTS) model to select uncertain parameters in the portfolio, and improved accuracy by applying some changes in the model. This method has also the ability to estimate the investment risk associated to possibilistic moments of trapezoidal fuzzy numbers. They implemented this method on Spain stock market, the results of which indicated that the proposed method had a higher prediction power than the classic one. Mishra et al. [16] proposed a new prediction based mean–variance model (PBMV) to select constrained portfolio assets. They predicted stock return using artificial neural network, and made use of particle swarm optimization (PSO) for the relevant weights of network. They also utilized Sign test and Wilcoxon rank test in order to compare the proposed method performance with Markowitz model. The findings demonstrated that this method had a better ability to produce Pareto solutions.

In recent years, in addition to increasing use of artificial networks, the use of Fuzzy C-means (FCM) approach has been increased. Using Fuzzy C-means and K-means algorithms in order to analyze data communication performance based on