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Analysis and control of variability by using fuzzy individual control charts

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ABSTRACT

The detection of changes in a process within shortest time provides significant benefits in terms of cost and quality. When considering the cost which would show up because of delays in identifying variability, detecting the deviation in the process accurately and quickly has a great importance for investors. In this paper, return volatility in the Borsa Istanbul-30 index (BIST-30) has been analyzed and a fuzzy control chart for individual measurements (FCCIM) has been proposed for use in determining and controlling in the variables of the BIST-30 index. For this purpose, firstly exponential smoothing method is used to forecast the variability of stock price of BIST-30 index by using MINITAB statistical software, and then a fuzzy control chart for individual measurements (FCCIM) which are fuzzy individual control chart (FICC) and fuzzy moving range control chart (FMRCC) with fuzzy control rules have been developed to be used in determining the variability of the process. For this aim, some fuzzy rules have been defined by using Ms EXCEL in fuzzy control chart for individual measurements. A real case application from Istanbul Stock Exchange for BIST-30 has been managed to check the effectiveness of suggested fuzzy control charts.

1. Introduction

Control charts monitor whether or not a process is under control. The chart contains three parts: a centerline that represents the average value of the quality characteristic corresponding to in-control state, and two other lines, called upper control limit (UCL) and lower control limit (LCL), which are chosen to assure that if the process is in-control, nearly all of the sample points will fall between them. Control charts have been widely used for monitoring process stability and capability [31]. Control charts can be applied in finance sector for the statistical analysis of the variables. Control charts, which developed W.A. Shewhart, today still continue its development by integrating new applications in different disciplines [45]. The use of classic control charts to analyze the variation in the process is suitable when the data are known precisely and exactly. However, it may not always be possible to determine the data clearly. When human subjectivity plays an important role in defining the quality characteristics, the classical control charts may not be applicable since they require certain information. The major contribution of fuzzy set theory lies in its capability of representing vague data. Fuzzy logic offers a systematic base to deal with situations, which are ambiguous or not well defined. Fuzzy control charts are inevitable to use when the statistical data in consideration are uncertain or vague; or available information about the process is incomplete or includes human subjectivity [47]. Decision analysis under uncertainty is often carried out with using the fuzzy set theory (FST). The FST developed by Zadeh is an effective tool for modelling uncertainties arising from mental structure of human [58]. Using the FST is inevitable with the situations such as uncertain, imprecise or the cases that include linguistic expressions. Because of the complexity, dynamism and high volatility in stock prices, the data cannot be fully determined. Fuzzy logic is a branch of mathematics that allows a computer to model the real world in the same way that people do. It provides a simple way to reason with vague, ambiguous, and imprecise input or knowledge [16,32,33,52]. Therefore the use of fuzzy control chart instead of the traditional control charts to analyze the variability in the process is required. For this aim, the FST has been integrated with control charts for individual measurements and two new fuzzy control charts named fuzzy *individual measurements control chart for (FIMCC) and fuzzy moving range control chart for (FMRCC)* have been proposed first time in this paper.

The use of FST in control charts has gained importance with the paper of Wang and Raz [55]. This paper was followed by the studies of Raz and Wang [43] and Taleb and Limam [48]. Wang and Raz [55] presented a probabilistic and membership approach to the control

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charts. [27] have expressed problems on the approach of Wang and Raz [55]. Gülbay and Kahraman [23] developed some new approaches for control charts that represented by linguistic data. Linguistic data including uncertainty is expressed by fuzzy numbers. In their paper, a new approach called Direct Fuzzy Approach was developed for fuzzy control charts. Gülbay and Kahraman [21] were also used the probability of fuzzy events on fuzzy abnormal process behavior tests. Erginel et al. [18] introduced the fuzzy standard deviation to obtain $\tilde{\bar{X}} - S$ control charts and then these fuzzy control charts are employed in food industry to monitor if the processes are under control or not. Şentürk et al. [47] developed one of the most popular control charts, exponentially weighted moving average control chart (EWMA) that can be used for detecting small shifts for univariate data under fuzzy environment.

In this paper, it is aimed to estimate the stock prices of BIST-30 Index which have high variability and to analyze the variability of the process by using fuzzy control charts. For this aim, the FST has been used with control charts for individual measurements – namely- *fuzzy individual measurements control charts* (*FIMCC*) and *fuzzy moving range control chart (FMRCC)* have been constructed and applied to measure the variability of the stock prices for BIST-30 Index. We apply fuzzy control charts for individual measurements in finance sector and applying α- cut approach for FIMCC and FMRCC by using α-cut mid-range approaches for the first time. In other words, fuzzy control charts for individual measurements have been revealed for the first time in this paper. The rest of this paper has been organized as follows: Section 2 summarizes the literature about estimation on financial sectors and fuzzy control charts. The proposed estimation method and suggested fuzzy charts for individual measurements have been detailed in Section 3. A real case application is given in Section 4 and finally Section 5 discusses the obtained results and future research directions.

2. Literature review

There have been many researches about the estimation of return/prices of financial assets in the literature. While the aforementioned studies before the 2000 s are mainly based on fundamental and technical analysis; quantitative methods have been used frequently in parallel with developments in the field of computer software as of this date. Özalp and Anagün [42] used classical estimation methods for forecasting the stock prices. They showed that the best solution was obtained with Exponential Smoothing and ARIMA models. Jonathan [35] presented whether financial ratios like dividend yield can predict aggregate stock returns. Chin and Hong [9] aimed to use the dividend yield, earning to price ratio, and capital gain to predict the Malaysia stock market return from 1995 to 2005 by using the time series regression. Deaves et al. [11] investigated theoretical and empirical determinants of Canadian aggregate stock price multiples. Elleuch and Trabelsi [15] determined a positive correlation between the future stock returns with using 12 financial ratios and accounting data as for the period 1995–2001. Kheradyar and Ibrahim [34] examined the role of financial ratios as empirical predictors of stock return in separate and combine sets for the period January 2000 to December 2009 in Malaysia. Dutta et al. [14] suggested using logistic regression and various financial ratios as independent variables to investigate indicators that significantly affect the performance of stocks actively traded on the Indian stock market. Atmeh and Dobbs [3] investigated the performance of moving average trading rules in an emerging market context, namely that of the Jordanian stock market. Vasiliou et al. [54] analyzed the performance of various technical trading rules in the Athens Stock Market and test two of the simplest and most popular trading rules- Moving Averages and MACD Indicator. They also evaluated how these simple forms of technical analysis can predict stock price movements in the Athens Stock Exchange. Tokuoka and Yamawaki [51] suggested a systematic method for predicting the trend of the price time-series at several ticks ahead of the current price by means of a genetic algorithm, used to optimize the combination of the frequently used technical indicators such as various moving averages, the deviation indicator from the moving averages, and so on. Metghalchi et al. [38] proposed testing moving average technical trading rules for the NASDAQ Composite Index. They showed that moving average rules indeed have predictive power and could discern recurring-price patterns for profitable trading. Sapena et al. [44] had used artificial intelligence techniques to stock prediction. Tektaş and Karataş [49] examined daily and weekly price information of seven stocks which were traded in ISE during the period of 2002–2003 and concluded that regression analysis given more successful results compared to the neural network. Jarrett and Schilling [25] tested the random walk hypothesis in the German daily stock prices by means of a unit root test and the development of an ARIMA model for prediction. Can and Öz [7] tried to estimate the price of exchange rate for 2008 based on the data of USA exchange rate between the years 1992–2007. As a result of analysis performed with hidden Markov Chains, the estimated foreign exchange had been shown to have high consistency. Tsai and Hsiao [50] aimed to combine multiple feature selection methods to identify more representative variables for better prediction with using three well-known feature selection methods, which are Principal Component Analysis, Genetic Algorithms and decision trees to effectively predict stock price. Vasanthi et al. (2011) tried to predict the stock index trend of various global stock indices using Markov Chain Analysis. They applied to the First Order Markov Chain Model to indices of various stock exchanges round the globe. Kara et al. [28] aimed to develop two efficient models which are based on two classification techniques, artificial neural networks and support vector machines and compared their performances in predicting the direction of movement in the daily Istanbul Stock Exchange (ISE) National 100 Index. Olaniyi et al. [40] used regression analysis for stock price prediction. They obtained data from the daily official list of the prices of all shares traded on the stock exchange published by the Nigerian Stock Exchange. Doubleday and Esunge [13] tried to determine the relationship between a diverse portfolio of stocks and the market as a whole. Dow Jones Industrial Average was analyzed using a discrete time stochastic model – Markov Chain. Ford et al. [19] considered the Stock Exchange futures market in Malaysia. They found that asset pricing model can be used as a rationale for the predictability of asset returns. Yang and Parwada [56] presented the conditional distribution of intra-day stock prices and predicted the direction of the next price change in an ordered-probit-GARCH framework that accounts for the discreteness of prices. Ayodele et al. [4] proposed a hybridized approach which combined the use of the variables of technical and fundamental analysis of stock market indicators for prediction of future price of stock in order to improve on the existing approaches. Yu et al. [57] examined whether the moving average and trading range breakout rules can forecast stock price movements and outperform a simple buy-and-hold strategy after adjusting for transaction costs over the period from January 1991 to December 2008. İlarslan [24] aimed to predict the future movement of the stock price with Markov chains. Daily closing prices of ten stocks which have been included to ISE 10 index were used in the paper. Results showed that the price of nine out of ten stocks is estimated a successfully. Apart from all these studies, this paper proposes an exponential smoothing method to forecast the variability of stock price of BIST-30 index by using MINITAB statistical software and fuzzy control charts for check the variability of stock price in Istanbul Stock Exchange. Exponential smoothing methods are optimal for a very general class of state-space models that is in fact broader than the ARIMA class [20]. It is also still maintain