Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 120 (2017) 365–371

Procedia Computer Science

www.elsevier.com/locate/procedia

9th International Conference on Theory and Application of Soft Computing, Computing with Words and Perception, ICSCCW 2017, 24-25 August 2017, Budapest, Hungary

Application of markov chains-fuzzy states to gold price

Berna Uzun[a,b]*, ErsinKıral[b]

[a]*Near East University, Near East Boulevard,POBOX: 99138 Nicosia, North Cyprus, Mersin 10 Turkey*
[b]*Çukurova University, 01330, Balcalı, Sarıçam, Adana, Turkey*

Abstract

The estimation regarding to the return rate of gold prices has been one of the most popular topic for the financial area due to its high return. Therefore, several research studies were carried out to predict the direction of the gold price movement. The aim of this research is to determine the probabilistic transition matrix of the closing returns of gold prices using Markov Chain Model of Fuzzy States (MCFS) with triangular fuzzy numbers. We used this method in order to consider the information while system moves between the extreme values of the states which are more realistic and flexible than the classical Markov Chain technique. With this study, we can say that the use of MCFS can give valuable information to the investors about the gold price movements.

Peer-review under responsibility of the scientific committee of the 9th International Conference on Theory and application of Soft Computing, Computing with Words and Perception.

Keywords: Gold price; fuzzy sets; markov chain with fuzzy states.

* Corresponding author. Tel.: +905338719838.
E-mail address: berna.uzun@neu.edu.tr

1877-0509
Peer-review under responsibility of the scientific committee of the 9th International Conference on Theory and application of Soft Computing, Computing with Words and Perception.
10.1016/j.procs.2017.11.251

1. Introduction

Gold is an internationally recognized financial asset that is valued as an investment vehicle all over the world. Gold prices are constantly changing. Nowadays, economic forecasts for the future, both individually and in terms of companies, have become very important. Forecasting of gold prices can be made in 3 ways as follows:

- Short-term forecasts: Hourly, daily or weekly
- Medium-term forecasts: Monthly or quarterly
- Long-term forecasts: Annual or longer processes.

The study includes monthly data between January, 2003 and January, 2017. The monthly weighted average of the gold price ($/ons) received from the Istanbul Gold Exchange has been used in the analysis.

Gold price estimation has always been important to governments, individuals and corporate investors. In previous years, several studies applied different algorithms and methods to train their model for gold price estimation.

Nowadays, neural network model is been considered by most research group to estimate gold prices. Research studies which use such model include, but not limited to, those conducted by (Mirmirani and Li, 2004), (Parisi et al., 2008), (Achireko and Ansong, 2000) and (Lineesh et al., 2010). Other models such as Autoregressive integrated moving average (Parisi et al., 2008), multi linear regression (Achireko and Ansong, 2000), (Escribanbo and Granger, 1998), (Ismail et al., 2009), (Kearney and Lombra, 2009), and Jump and dip diffusion (Shafiee and Topal, 2010) were also used for gold price forecasting.

Markov process is a stochastic model that has the Markov property. It can be used to model a random system. Markov decision processes (MDPs) give mathematical framework for modelling the situations where outcomes are partly random and partly under the control of a decision maker. This model relies on crisp states which lead to counting the movements between extreme values of the states, as the movements between average values of the states.

Zadeh (1965) defined fuzzy sets in order to describe unclear situations mathematically. Thomason (1977) introduced fuzzy matrix and Kruce et al. (1987) introduced the fuzzy Markov chain as a classical Markov chain based on fuzzy probabilities. Fuzzy Markov chain is demonstrated as the concept of fuzzy relation and its compositions (Sanchez, 1976). It can be used while the decision maker prefers subjective probabilities to model the uncertainties (Vajargah and Gharehdaghi, 2012). Yoshida (1994) generated a Markov fuzzy model with a transition possibility measures. Slowinski (1998) showed that we can use a fuzzy set representation in order to deal with uncertain data and flexible requirements. Avrachenkov and Sanchez (2000) analyzed fuzzy Markov chains and its properties in detail. Kuranoa et al. (2006) used fuzzy states to show fuzzy transition probabibilities. Pardo and Fuente (2010) used Markovian decision processes with fuzzy states to calculate the best policy to be implemented regarding publicity decisions in a queueing system. Zhou et al. (2013) used fuzzy probability-based Markov chain model to estimate regional long-term electric power demand. Ky and Fuente (2016) used combination of Markov model and fuzzy time series model for forecasting stock market data. Kıral and Uzun (2017) used Markov chain of the fuzzy states to estimate stock market index.

In order to deal with uncertain and complex nature of the gold price movements, we used MCFS technique. For this aim, we categorized the closing returns of the gold prices return data as fuzzy states with the triangular fuzzy sets. Then we determined the Markov transition matrix of the fuzzy states. Furthermore, we estimated the preceding month expected gold price return.

2. An overview of the fuzzy sets

Here, we give fundamental definitions about fuzzy set theory.

Definition 1. A fuzzy set $\tilde{A}$ in IR is a set of ordered pairs:

$$\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) | x \in IR\} \tag{1}$$