Applied Soft Computing 45 (2016) 40–60

Contents lists available at ScienceDirect

Applied Soft Computing

journal homepage: www.elsevier.com/locate/asoc

An evolutionary hybrid Fuzzy Computationally Efficient EGARCH model for volatility prediction

Rajashree Dash, P.K. Dash *

Siksha 'O' Anusandhan University, Khandagiri Square, Bhubaneswar, OR, India

ARTICLE INFO

Article history:
Received 19 November 2014
Received in revised form 31 March 2016
Accepted 11 April 2016
Available online 22 April 2016

Keywords:
Volatility prediction
Stock markets
GARCH model variants
Fuzzy logic based hybrids
Fuzzy inference with nonlinear functions
Multistep prediction
Differential evolution
Super predictive ability test

ABSTRACT

Accurate modeling for forecasting of stock market volatility is a widely interesting research area both in academia as well as financial markets. This paper proposes an innovative Fuzzy Computationally Efficient EGARCH model to forecast the volatility of three stock market indexes. The proposed model represents a joint estimation of the membership function parameters of a TSK-type fuzzy inference system along with the leverage effect, asymmetric shock by leverage effect of EGARCH model in forecasting highly nonlinear and complicated financial time series model more accurately. Further unlike the conventional TSK type fuzzy neural network the proposed model uses a functional link neural network (FLANN) in the consequent part of the fuzzy rules to provide an improved mapping. Moreover, a differential evolution (DE) algorithm is suggested to solve the parameters estimation problem of Fuzzy Computationally Efficient EGARCH model. Being a parallel direct search algorithm, DE has the strength of finding global optimal solutions regardless of the initial values of its few control parameters. Furthermore, the DE based algorithm aims to achieve an optimal solution with a rapid convergence rate. The proposed model has been compared with some GARCH family models and hybrid fuzzy systems and GARCH models based on three performance metrics: MSFE, RMSFE, and MAFE. The results indicate that the proposed method offers significant improvements in volatility forecasting performance in comparison with all other specified models.

1. Introduction

Modeling and forecasting stock market volatility have received a great interest from researchers in academia as well as in financial markets due to its wide range of applications from risk measurement to asset and option pricing. Investment decisions in financial markets strongly depend on the forecast of expected returns and volatilities of the assets. Volatility provides a measure of fluctuation in a financial security price around its expected value. Expected Market return is highly related to predictable stock market volatility. Due to the necessity of volatility prediction, a large number of time series models have been developed for financial data with changing variance over time. GARCH family models play a key role among them. Bollerslev (1986) introduced the Generalized ARCH (GARCH) model, which combines the ARCH and autoregressive moving average (ARMA) models. The GARCH model reflects the non-linear dependence of the conditional variance of the time series, estimating jointly a conditional mean and conditional variance [1,2]. Despite the success of GARCH model, it fails to capture the asymmetric volatility, since the volatility of stock prices is greatly affected by negative shocks to returns rather than positive shocks. The GARCH model does not recognize the transmission of volatility that come from the input of positive or negative information. Therefore, this model is not appropriate when the market is asymmetric. Further the GARCH volatility forecasting models can be divided broadly into distribution (GARCH-N, GARCH-t, GARCH-HT and GARCH-SGT) and asymmetry-type (GJR-GARCH and EGARCH) models and extensive studies to predict S&P-100 stock index volatility are presented in Refs. [3–5] using both category of models. The conclusion of this study indicated that the asymmetry-type GARCH models outperformed the volatility forecasts using the error distribution types.

Although, many financial time series observations have nonlinear dependence structure, a linear correlation structure is usually assumed among the time series data. However, conventional time series models produce forecasts based on some strict statistical assumptions about data distributions, and, therefore, they are not very proper to forecast financial datasets [6]. Also due to their complexities, nonlinear models are in very limited use today. Considering these difficulties, there is currently a demand

* Corresponding author.
E-mail addresses: pkdash.india@gmail.com, dashpk13@yahoo.com (P.K. Dash).

http://dx.doi.org/10.1016/j.asoc.2016.04.014

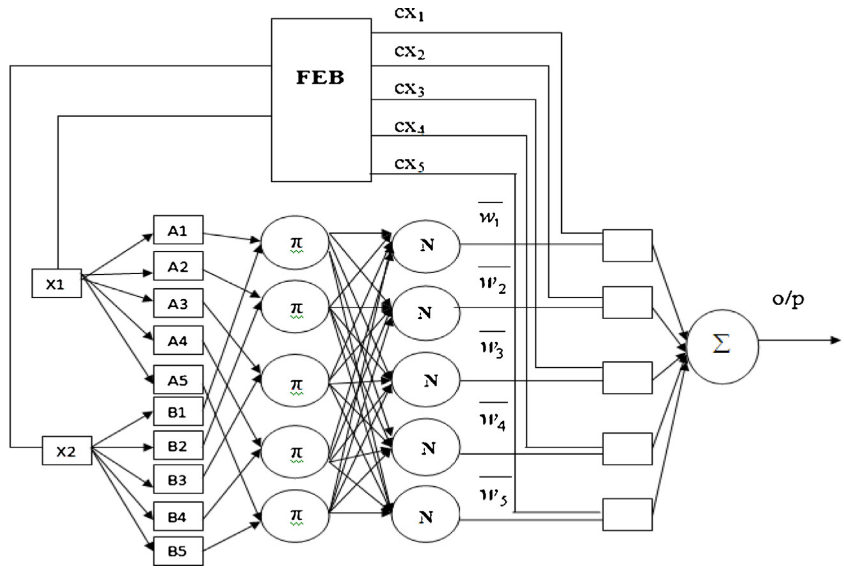

Fig. 1. Architecture of Fuzzy CE-EGARCH Model with $p = 1$, $q = 1$ and $n = 2$.

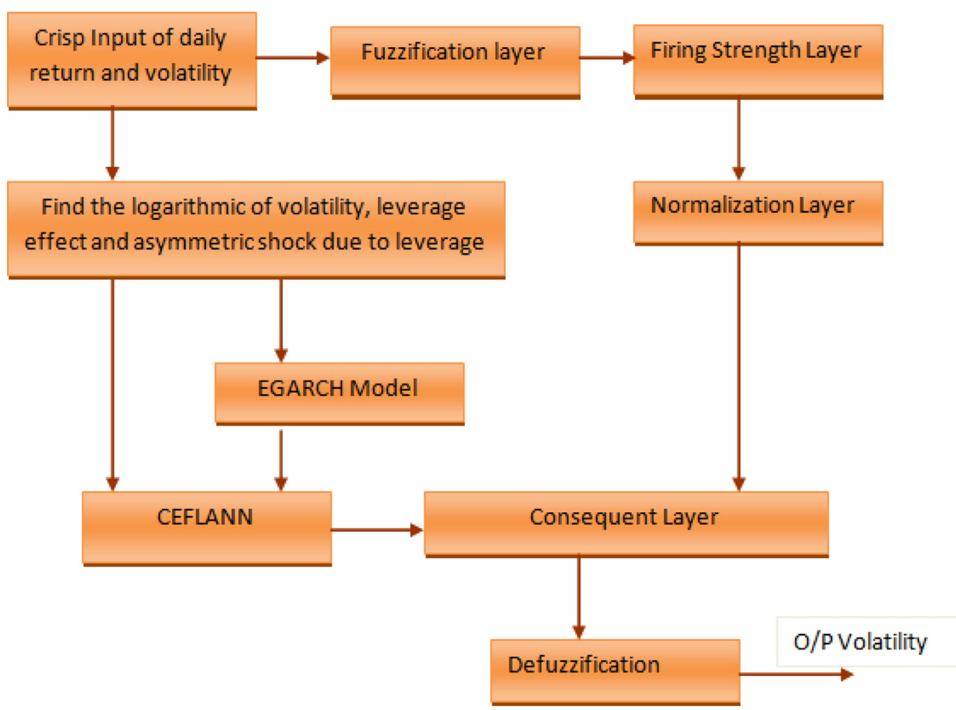

Fig. 2. Framework of the proposed Fuzzy CE-EGARCH model.

for more flexible models. In the evolution of time series models, researchers have made extensive efforts to take advantage of artificial intelligence to process an extensive amount of information, and to forecast financial markets leading to an increase in investment return. To enhance the predictive power of the financial time series models, the traditional time series models are hybridized with the neural networks for volatility prediction of different benchmark financial datasets [7–11]. The attempt for hybrid system is to outperform the forecast results and overcome the shortcomings by extracting input variables from statistical methods and include them in ANNs learning process. Despite the high ability to deal with the problem of volatility forecasting, ANN drawbacks include its "black box" nature, greater computational burden, proneness to over fitting, and the empirical nature of model development. Again to overcome the drawbacks of neural network models and to tackle the uncertainties that exist in accurate forecasting of stock market volatility, several fuzzy time series models have evolved. The hybrid fuzzy time series models proposed in Refs. [14–17] have shown significant improvements in forecasting stock market volatility, outperforming the traditional time series models, neural network and other hybrid models, etc. Adaptive Neuro-Fuzzy information system (ANFIS) is another popular hybrid model used in volatility forecasting [18–20,24]. The ANFIS model provides the advantage of combining the rules in the rule base of fuzzy theory to describe the complex relationships between the variables and the learning ability of neural network to adjust the membership functions and rule base. Further the ANFIS model provides a better approach of using the low level learning, computational power of