The Spanish Review of Financial Economics xxx (2017) xxx–xxx

The Spanish Review of Financial Economics

AEFIN The Spanish Finance Asociation

www.elsevier.es/srfe

Article

Hybrid multiple structural break model for stock price trend prediction

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ARTICLE INFO

Article history:
Received 27 December 2016
Accepted 25 February 2017
Available online xxx

JEL classification:
G17
C53
C45
C63
C11

Keywords:
Multiple structural breaks modelling
Stock trend prediction
Forecast combination
Markov switching model
Bayesian regularized radial basis function network
Trading strategy

ABSTRACT

Because of the noises from the internal and external factors, the uncertainty increases in the financial market. The challenges of nonlinearities, volatility clusters, and multiple structural breaks which entail risk. Due to the risk, the prediction task becomes more complex. First, this work proposes a hybrid model to predict the one-day future price for the stocks; MSFT, Apple, Goldman Sachs and JP Morgan use the Markov switching model coupled with radial basis function network for prediction. Second, this paper forecasts the buy/sell trading strategy using the proposed hybrid method. Also, this paper explores the risk of investment decisions and the trading performance based on different value at risk (VaR) methods. Finally, by comparing the proposed model results with the pure linear and non-linear models, the prediction efficiency is evaluated. The experimental results indicate the investment risk, and the investment trading strategy provides a better accuracy with the best investment decision for the selected stocks.

1. Introduction

Structural break, volatility modelling, and forecasting problems are considered as important tasks in the financial time series applications. This paper introduces a novel hybrid architecture called Markov switching Autoregressive model (4) combined with Bayesian Regularized Radial Basis Function Neural Network MSAR (4) (BR-RBFN) as a forecaster. Recently, researchers are attracted towards the pole of the stock price trend prediction which is embodied an increasing development in the model building process for evaluating the better investment stocks in the trading business. These models provide an investment trading insight to the investors who are forging the business deals in the trading market. Now, this profit maximization model demands an efficient market situation where investors are expected to yield a higher profit. However, if the market is efficient, it is not always easy to anticipate an investor who can yield a maximum profit than those who are holding the random stocks (Malkiel, 2003). So, it is vital to evaluate the unit root test with the presence of multiple structural changes for efficient market hypothesis.

Naturally, the impulses (structural changes, conflicting behaviour, and political policy changes) from the internal and the external factors are predominantly changing the price direction. Thus, these deterministic changes and inherent noises make the prediction task even more complicated. The cornerstone of the prediction is that if the stock returns are mean revert, it will be possible to forecast the future trend using the past information data, as given in Malkiel and Fama (1970). There are a number of studies dealing with the efficient market hypothesis by examining the random walk analysis using different unit root tests for the emerging market (Gough and Malik, 2005; Lim and Brooks, 2011; Mishra et al., 2015; Borges, 2010). However, very few studies have allowed the structural changes in the unit root test for improving the prediction performance of the considered model. A study in the US on monthly natural gas consumption with the presence of GARCH unit root test and structural breaks has suggested that there is strong evidence of stationarity in the data, as mentioned by Mishra and Smyth (2014). Using macroeconomic time series data, a comparative analysis of structural break has been analyzed for improving the prediction performance (Bauwens et al., 2015).

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http://dx.doi.org/10.1016/j.srfe.2017.02.002
2173-1268/

Please cite this article in press as: Gopal, S., Ramasamy, M., Hybrid multiple structural break model for stock price trend prediction. Span Rev Financ Econ. (2017). http://dx.doi.org/10.1016/j.srfe.2017.02.002

Based on the mathematical Bai-Perron technique, the housing price of the United States has been predicted by the presence of multiple structural breaks (Barari et al., 2014).

A number of studies have been analyzed for understanding the importance of parametric and non-parametric models, which are used in the application of time series forecasting. In finance, stock return prediction of Intraday S&P 500 index has been evaluated to improve the prediction accuracy as discussed in Matías and Reboredo (2012). This study suggests that the non-linear models surpassed the traditional linear models such as random walk on the basis of both statistical and economic criteria. In order to estimate and fine-tune the parameters of the non- linear STAR model, an evolutionary programming based on genetic algorithm has been utilized for forecasting the Eurozone peripheral stock market provided in Avdoulas et al. (2015). This study discusses the important implication of the market efficacy and predictability in terms of the investment trading strategies.

In recent years, Artificial Neural Networks play a major role in predicting the stock price trends (Ghiassi et al., 2005; Roh, 2007; Hamzaçebi et al., 2009; Patel et al., 2015). Oil price forecasts have been reviewed using the following price forecasting techniques such as ANN, genetic algorithm, support vector machine and hybrid system, which have been elaborated in Sehgal and Pandey (2015). Thereafter, a number of advanced mathematical techniques including fuzzy logic, genetic algorithm, and Bayesian probability have been exploited to improve the stock price trend prediction (Atsalakis and Valavanis, 2009; Chen et al., 2007; Chang, 2012; Ticknor, 2013; Sun et al., 2014; Ariyo et al., 2014). To perceive the plague of overfitting and overtraining of the neural network and to improve the network generalization, many hybridized studies have been developed for stock price trend prediction (Babu and Reddy, 2014; Adhikari and Agrawal, 2014). For predicting the electricity price, a hybrid ANN model has been proposed by Chaâbane (2014). The potential benefits and impact of accurate stock market prediction of Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX), Dow-Jones Industrial Average (DIA), S&P 500 and IBOVESPA Stock Index have been investigated by Chen and Chen (2015). Similarly, a combination of genetic algorithm with support vector machine has been modified to uncover the short-term trading efficiency of ASE 20 Index, which has been evaluated by Karathanasopoulos et al. (2015). Although there are many potential linear and non-linear stock price trend prediction models available in the academic literature, it is worthy of mention that no single model is best in all situations (Zhang, 2004).

First, this paper proposes a novel architecture in order to improve the strength of each non-linear model such as Markov switching model and radial basis function network model to predict the one-day future stock price for the four major stock returns. Then, this proposed model finds its predictive ability and improves the network generalization, as well as overcoming the plague of network overfitting and overtraining. Though there are a number of studies available on risk modelling, the single model reliability is still questionable. To the best of our knowledge, the combination of two non-parametric models has not yet contributed to the burgeoning literature for predicting the future stock returns.

Second, this study predicts the buy/sell trading days for the considered stock returns to improve the trading performance using the hybrid optimal cost function. Also, this paper investigates the investment decision peril based on the value at risk forecasts (VaR) using the parametric methods such as MA, EWMA, GARCH, historical simulation and expected shortfall. Finally, by comparing the proposed model results with the traditional Random walk linear model (RW) and the non-linear models such as Smooth transition autoregressive model (STAR), Multilayer Perceptron network (MLP), and Random forest network, the prediction efficiency is evaluated.

The rest of the paper is structured as follows. Section 2 describes the methodology of the proposed hybrid model; Sections 3 and 3.1 consider the data and the technical indicators and their importance; Section 4 discusses empirical analysis; Section 4.1 confers the results of the predictive hybrid model; finally, Section 5 summarizes the conclusions of this study.

2. Methodology

2.1. Markov switching model

A non-linear threshold Markov switching model has potentially been employed to estimate the multiple structural changes and to predict the one-day future diurnal stock return patterns. The effects of structural shocks are characterized over two-regimes in the parameter estimation. During the model building process, this model's flexibility allows the different types of behavioural patterns for the considered stock returns at different points in time. Hence, it helps to capture the multiple structural changes in the data and provides useful signal about the market activities.

Basically, Markov switching model by Hamilton (1996) implies that the probability distribution of an unobserved variable y_t lying in the interval $\{a, b\}$ depends on their state at the time $t-1$ and not on any previous states.

Let us consider the unobserved state variable be S_t. Now the series of each considered stock data can be represented as follows:

$$y_t = \mu_0 + \mu S_t + (\sigma^2 + \theta){S_t}^{1/2} * \varepsilon_t \quad (1)$$

$$\mu S_t = \mu_1 S_{1t} + \cdots + \mu_M S_{Mt} \quad (2)$$

$$\sigma^2 S_t = \sigma_1^2 S_{1t} + \cdots + \sigma_M^2 S_{Mt} \quad (3)$$

where $\varepsilon_t \sim N(0, 1)$. In state 1, the expected returns and the error variances are represented as (μ, σ^2). Similarly, in state 2, they are $(\mu_0 + \mu, \sigma^2 + \theta)$. The unknown parameters $\mu_0,\ \mu,\ \sigma_0^2,\ \sigma^2,\ p11,\ p22$ can be estimated using maximum likelihood method. An easily computable technique called the Hamilton filter gives statistically significant values for the unknown parameters based on its means.

2.2. Bayesian regularized radial basis function network

In 1988, Broomhead and Lowe exploited the use of radial-basis functions in the design of the neural network. The radial basis function network is a three-layered architecture labelled as the input layer, a hidden layer, and the output layer (Broomhead and Lowe, 1988) as illustrated in Fig. 1. The input layer consists of 10 nodes of input neurons X_i. The hidden layer consists of the same number of evaluation units as the size of the training sample N; each unit is mathematically described by a radial basis function F that has the following structure:

$$F(x) = \sum_{i=1}^{N} \omega_i \varphi(X - X_i) \quad (4)$$

where $\{\varphi(X - X_i) | i = 1, 2, \ldots, N\}$ is a set of non-linear function known as radial-basis functions and $||.||$ denotes a norm. The known data points $X_i \in \mathbb{R}^{m_0},\quad i = 1, 2, \ldots, N$ are considered to be the centres of the radial-basis functions. Basically, high-dimensional space leads to the problem of the multivariable interpolation problem (Davis, 1963). Therefore, this interpolation problem can be stated as follows:

$$F(X_i) = v_i, \quad i = 1, 2, \ldots, N \quad (5)$$

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