Novelty Journals

ISSN 2394-9651

International Journal of Novel Research in Physics Chemistry & Mathematics
Vol. 6, Issue 2, pp: (1-7), Month: May - August 2019, Available at: www.noveltyjournals.com

Sama Circular Model and ARIMA on Forecasting BSE Sensex

DR. W. G. Samanthi Konarasinghe

Institute of Mathematics & Management, Ranala, Sri Lanka
E mail: sinasisi@gmail.com

Abstract: **The Indian stock market has a long history and a significant place in the global market. It is known that performances of Indian stock market affect the nearby share markets as well as the far away markets. The Bombay Stock Exchange (BSE), one of the largest stock markets of the world, is the first Indian stock market exchange. As such predictions on BSE were immense interest of the investors. Hence, the S&P BSE Sensex index, which measures the performances of top 30 listed companies of the exchange, was one of the main interests of researchers. According to literature, Fundamental analysis, Technical analysis and Artificial Neural Network were applied on forecasting BSE Sensex. Among the tested model, the Auto Regressive Integrated Moving Average (ARIMA) model is identified as a highly successful technique for the purpose. Yet academicians have highlighted some major weaknesses of the model. The Sama Circular Model (SCM) is a univariate forecasting technique. Literature revealed that the SCM is capable in overcoming those weaknesses. Therefore the study is focused to; test the SCM and ARIMA on forecasting S&P BSE Sensex index and compare the forecasting ability of them.**

Keywords: **Index, Technical Analysis, Forecasting, ARIMA, Sama Circular Model.**

I. INTRODUCTION

A stock market or share market is a network of transactions of financial instruments; shares or stocks, bonds, mutual funds, derivatives etc. The stock market plays a vital role in the growth of the industry and commerce of the country; hence affects the economy of the country to a great extent. Therefore, the government, industry and the central bank of the country keep a close watch on the happenings of the stock market. Share market investment yields high return, but associated with high risk. Therefore investors are very much concern on predictions of share markets. At one time share market predictions were totally depending on knowledge and intuition of the market experts, but later in 1950's scientific forecasting became more popular in the field.

Scientific forecasting is based on mathematical modeling. Mathematical models can be classified in many ways. Some of them are: static models, dynamic models, deterministic models and stochastic models. A model is said to be static when it does not have time-dependent component. In contrast, dynamic models contain time-dependent component. A deterministic model is one in which every set of variable states is uniquely determined by parameters in the model and by sets of previous states of these variables. Deterministic models are not associated with any randomness. Conversely, in a stochastic model, randomness is present and variable states are described by associated probability distributions. In general stochastic models are referred as Statistical models.

Statistical models are divided into two parts; univariate models and multivariate models. Univariate statistical model is an equation or set of equations that explain the behavior of single random variable over time while multivariate statistical models explain the joint behavior of two or more random variables. Smoothing Techniques, Decomposition Techniques and Auto Regressive Integrated Moving Average (ARIMA) method were the widely applied univariate forecasting techniques in the analysis of time series (Stephen, 1998). Traditional time series models assume a constant one-period forecast variance. Engle (1982) generalize this implausible assumption, introducing a new class of stochastic processes

called Auto-Regressive Conditional Heteroscedasticity (ARCH) processes. The Generalized Auto Regressive Conditional Heteroscedasticity (GARCH) model is an improvement of ARCH model. At present ARCH and GARCH models also play a significant role in time series forecasting. Sama Circular Model (SCM) is a recently joined member to the family of Univariate forecasting techniques.

In general, performances of stock markets are measured by stock market indices. Stock market indices give the direction of the entire market, part of it or business sectors. An increase in the index indicates a rising market; a decreasing in the index indicates a falling market; fluctuation of the index series shows the volatility of the market. These patterns give insights to the investment decisions, as such forecasting market indices were an immense interest over the decades. Stock market indices are classified into several types, based on the method of weighting in index calculation. Accordingly, main types of indices are; equally weighted indices, price-weighted indices, value-weighted indices and float adjusted indices.

Statistical techniques and soft computing techniques are the two types used in stock market forecasting. Statistical techniques comprise of Fundamental analysis and Technical analysis. The fundamental analysis involves analyzing the economic factors or characteristics of a company, namely; company value, company earnings, book-to-market equity etc. The technical analysis analyses the price movements and trading volume in the market. Technical analysis comprises both Univariate and Multivariate techniques. The ARIMA, a univaratie technique was highly successful in share market forecasting. Studies; Prapanna, Labani and Saptarsi (2014) on Indian stock market; Emenike (2014) based on Nigerian Stock Exchange (NSE); Ayodele, Aderemi and Charles (2014) for New York stock Exchange; Rosangela, Ivette, Lilian, and Rodrigo (2010) on Brazilian stock market; Konarasinghe, Abeynayake and Gunaratne (2015) on Sri Lankan stock market etc. evidenced the success of ARIMA in share market forecasting.

PROBLEM STATEMENT

Investopedia, the American website focuses on investing and finance education says; “There are two kinds of investors: those who know about the investment opportunities in India and those who don't”. It shows the prominent place of the Indian stock market in the globe and the promising opportunities to the investors. Most of the trading activities in the Indian stock market are taken places on its two stock exchanges: the Bombay Stock Exchange (BSE) and the National Stock Exchange (NSE). The Bombay Stock Exchange (BSE), begun in 1875 is the Asia’s first stock exchange. The BSE have more than 5,000 listed firms; hence become the world's No. 1 exchange in terms of listed members. The S&P Bombay Stock Exchange Sensitive Index or the BSE Sensex Index is the oldest and one of the most prominent indices in the Indian market. The BSE Sensex is a free-float market-weighted index. It captures the performances of 30 well-established and financially sound companies listed in Bombay Stock Exchange. As such many researchers have attempted to forecast the BSE Sensex by establishing various techniques. Yet, some of the researchers claim that the existing techniques are not sufficient for the purpose. For example; Agrawal, Chourasia and Mittra (2013) have reviewed the existing methods for prediction of Indian stock market and discuss various advantages and limitations of these methods.

Literature revealed that the ARIMA technique was successful in forecasting Indian stock market indices. Yet the ARIMA technique has few weaknesses. Studies of; Ayodele et. al. (2014), Konarasnghe (2016) and many others have shown that the ARIMA forecasts do not follow the pattern of actual series. Also, ARIMA can be applied only if the data series has constant mean and constant variance (stationary series). On the other hand, ARIMA is unable to separate the seasonal and cyclical variations of a series. In contrast, the Sama Circular Model (SCM) is applicable in modeling non stationary series, and also capable in differentiating seasonal and cyclical variations of a series. Preliminarily data analysis of the study revealed that the Indian stock market indices follow wave like patterns with trends. Hence it is important to find suitable forecasting techniques to fulfill the expectations of investors.

Objectives of the study

i. To test the SCM on forecasting BSE Sensex index

ii. To test the ARIMA on forecasting BSE Sensex index

iii. To compare the forecasting ability of SCM and ARIMA

Novelty Journals

ISSN 2394-9651

International Journal of Novel Research in Physics Chemistry & Mathematics
Vol. 6, Issue 2, pp: (1-7), Month: May - August 2019, Available at: www.noveltyjournals.com

II. METHODOLOGY

The study is based on the Sama Circular Model (SCM) of Konarasinghe (2018) and the ARIMA model of Box and Jenkins (1970). Monthly S&P BSE Sensex data from January 1980 to April 2019 were obtained from the official website of Bombay Stock Exchange. Box plots and Time Series plots were used for pattern recognition. Then the SCM and ARIMA were tested, using software Minitab 17. Goodness of fit tests and measurements of errors were used in model validation. The Auto Correlation Functions (ACF) of residuals and Ljung-Box Q statistics (LBQ) were used to test the independence of residuals. The Probability plot and the Anderson Darling test were used to test the normality of residuals. Forecasting ability of models was assessed by Mean Square Error (MSE) and Mean Absolute Deviation (MAD).

Sama Circular Model (SCM)

The SCM is the improved form of the Circular Model (CM) of Konarasinghe (2016). Development of the CM was based on the Fourier transformation (FT). The FT can be used to transform a real valued function f(x) into series of trigonometric functions (Philippe, 2008). A particle *P*, which is moving in a horizontal circle of centre O and radius *a* is given in Figure 1. The ω is the angular speed of the particle;

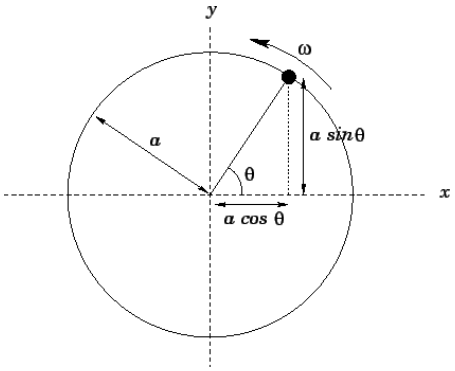

Figure 1: Motion of a particle in a horizontal circle

For a random variable Y_t, the CM is written as;

$$Y_t = \sum_{k=1}^{n}(a_k \sin k\omega t + b_k \cos k\omega t) + \varepsilon_t \quad (1)$$

The limitation of the CM is that, the model is not applicable for series with trend. The SCM mitigates it by using the differencing technique. Hence the SCM is;

$$(1-B)^d Y_t = \sum_{k=1}^{n}(a_k \sin k\omega t + b_k \cos k\omega t) + \varepsilon_t \quad (2)$$

Where; d th order difference of $Y_t = Y_t^d = (1-B)^d Y_t$, B is the Back Shift operator.

Assumptions of the SCM are; Series $\sin k\omega t$ and $\cos k\omega t$ independent, Residuals (ε_t) are normally distributed and independent.

ARIMA Model

The ARIMA model was introduced by Box and Jenkins in 1970. In the ARIMA model, future value of a variable is a linear combination of past values and past errors, expressed as;

$$\phi_p(B)\Delta^d Y_t = \theta_q(B)\varepsilon_t \quad (3)$$

Where, Y_t is the actual value, ε_t is the random error at time t, ϕ_p and θ_q are the coefficients of autoregressive and moving average, respectively. B is the back shift operator.

Novelty Journals

ISSN 2394-9651

International Journal of Novel Research in Physics Chemistry & Mathematics
Vol. 6, Issue 2, pp: (1-7), Month: May - August 2019, Available at: www.noveltyjournals.com

III. FINDINGS

In general, two primary trends are identified in stock markets; "Bull market and Bear market". Bull market which is represented by bull symbol signifies upward market trend where as bear symbol represents a general decline in the market. The bear market rally and bull market rally are short lived; secondary trends in the market. In a bear market rally, share prices show temporary increase; in a bull market rally, share prices show temporary decrease.

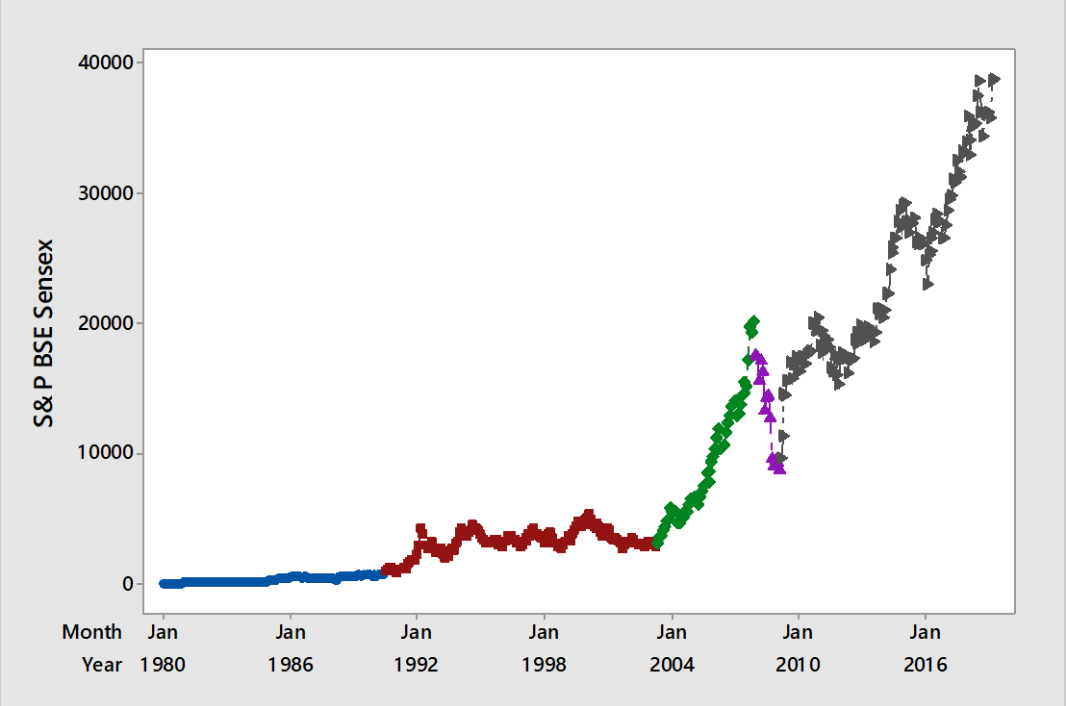

Figure 2: Time Series Plot of S&P BSE Sensex

Figure 2 is the Time series plot of S&P BSE Sensex. It shows an overall increasing trend, yet it has several clear phases. From January 1980 to June 1990, the index is almost stable, and then fluctuates a little up to April 2003. Then a Bull market begins and lasts for more than four years, until December 2007. After that a Bear market continues for 14 months. Thereupon, it shows several bull market rallies between March 2009 and April 2019. Hence the data series from year 2009 was used for model testing. Data from January 2009 to March 2017 was used for model fitting and April 2017 to April 2019 was for model verification. Log transformation was applied on data for convenience.

TESTING SAMA CIRCULAR MODEL (SCM) ON BSE SENSEX

The BSE Sensex series (Y_t) in Figure 3 shows a wave like pattern with trend, but the first difference series (X_t) in Figure 4 is trend free. Hence, the Circular Model (CM) was tested on X_t.

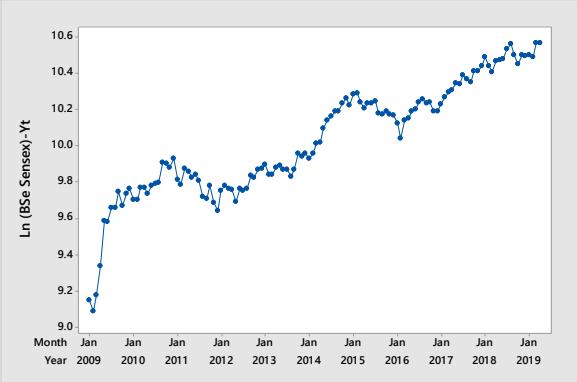

Figure 3: TS Plot of Y_t

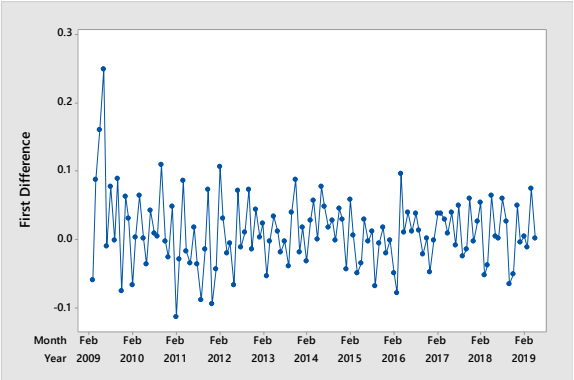

Figure 4: TS Plot of X_t

Novelty Journals

ISSN 2394-9651

International Journal of Novel Research in Physics Chemistry & Mathematics
Vol. 6, Issue 2, pp: (1-7), Month: May - August 2019, Available at: www.noveltyjournals.com

As explained in Konarasinghe (2016), the angular speed ω was calculated by, $\omega = 2\pi f / N$; Where f is the number of peaks and N is the number of observations in the series. For this series, f=37 and N=123; hence ω =1.8901. Then, the 12 trigonometric series; $\sin k\omega t$ and $\cos k\omega t$ for k=1 to 6 were obtained. The correlation analysis confirmed the independence of these series. Therefore, X_t was regressed on them. The best fitting model is; $X_t = 0.01191 + 0.01727 \cos \omega t - 0.01548 \cos 4\omega t$.

Normality of the residuals was confirmed by the probability plot and Anderson Darling test. The Auto Correlation Functions (ACF) of residuals and Ljung-Box Q statistics (LBQ) confirmed the independence of residuals. Measurements of errors; MSE and MAD are very small in both model fitting and model verification (given in Table 1). Hence, the best fitting Sama Circular Model for forecasting BSE Sensex (Y_t) is;

$$Y_t = Y_{t-1} + 0.01191 + 0.01727 \cos \omega t - 0.01548 \cos 4\omega t \quad (4)$$

The fitted model, given in (4) comprises two trigonometric functions; $\cos \omega t$ and $\cos 4\omega t$. In other words the motion of BSE Sensex comprises two circular motions; circle C1 with angular speed ωt and radius 0.01727, circle C2 with angular speed $4\omega t$ and radius 0.01548. Waves related to circular motions C1 and C2 are given in Figure 5 and Figure 6 respectively;

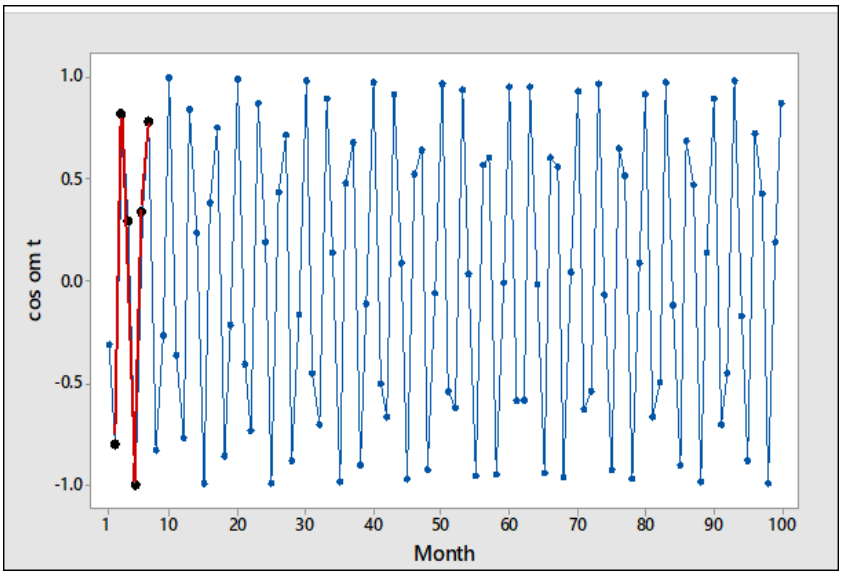

Figure 5: Wave C1

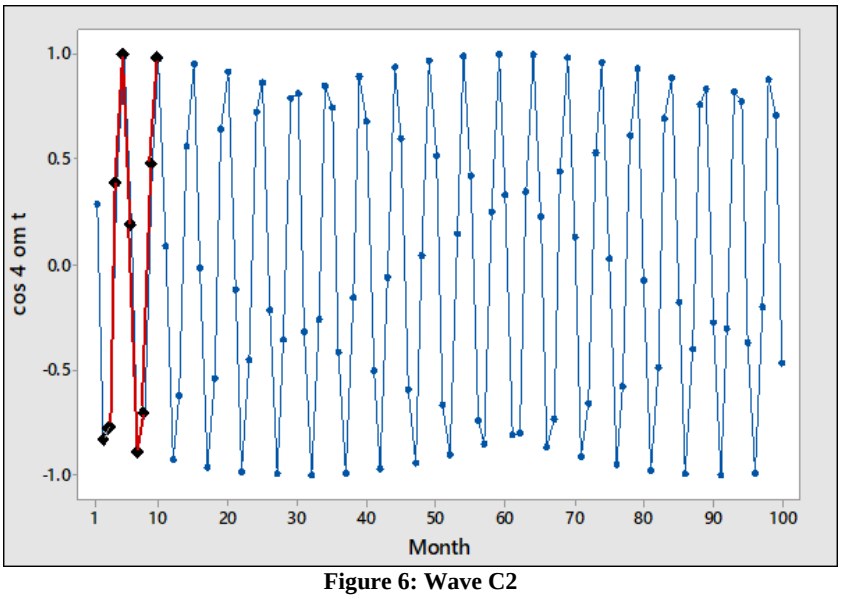

Figure 6: Wave C2

The wave C1 is an irregular wave with period of oscillation 6 months. The wave C2 is an irregular wave with period of oscillation 9 months. It is clear that the BSE Sensex index follows two seasonal variations.

TESTING ARIMA ON BSE SENSEX

The Auto Correlation function of log transformed data was obtained and found that the stationary criterion is met at differencing. Then several ARIMA models were tested and found that the best fitting model is ARIMA (0, 2, 1). Residuals of the model are normally distributed and independent; measurements of errors are satisfactorily small (given in Table 1). Therefore ARIMA model is suitable in forecasting BSE Sensex.

COMPARISON OF FORECASTING ABILITY OF ARIMA AND SCM

Table 1 has measurement of errors in model fitting and verification for both ARIMA and SCM. Mean square error and mean absolute deviation in model fitting are almost equal in both ARIMA and SCM, but measurements of errors of SCM are smaller in model verification. Accordingly, SCM forecasts would be more accurate than those of ARIMA.

Table 1: Measurement of Errors

Model	Model Fitting		Model Verification	
	MSE	MAD	MSE	MAD
ARIMA	0.002970	0.0409664	0.0365083	0.171377
SCM	0.00265735	0.0381846	0.00192919	0.0347656

BSE Sensex data from May 2017 to March 2019 were plotted with forecasted values of ARIMA and SCM for the same period. Figure 7 is the Time series plot of Actual Index Vs ARIMA forecasts and SCM forecasts. It clearly shows that the SCM forecasts follow the pattern of actual indices. In contrast, ARIMA forecasts follow a totally different pattern. Also ARIMA forecast were underestimates to actual index values.

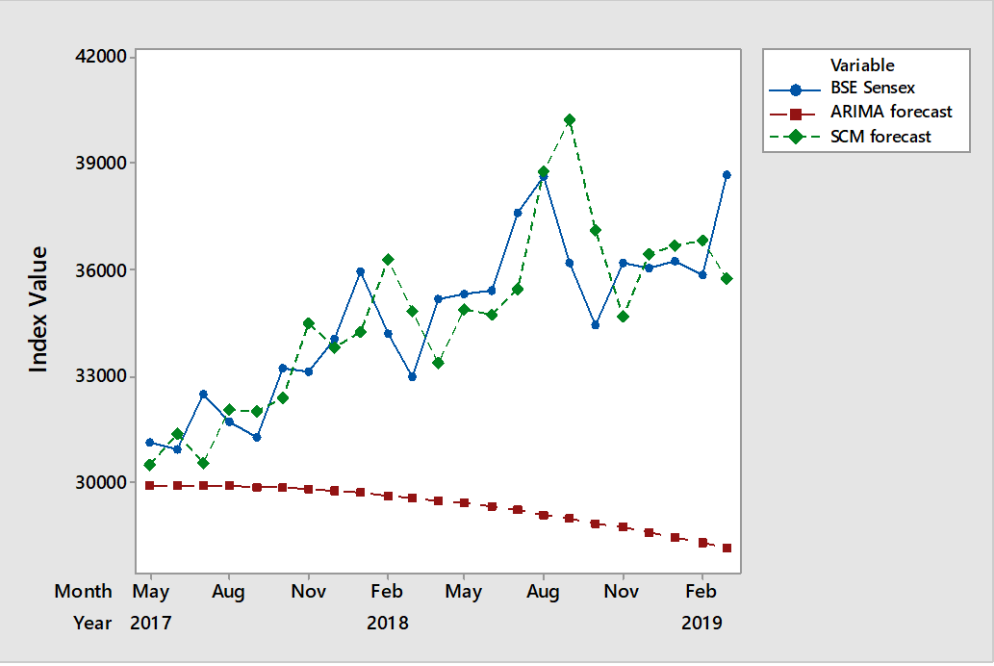

Figure 7: Time Series Plot of Actual Vs Forecasts

IV. CONCLUSION

The study was aimed to forecast the BSE Sensex index and compares the forecasting ability of ARIMA and SCM for the purpose. It is concluded that both ARIMA and SCM are suitable in forecasting BSE Sensex. Also it is concluded that the Sama Circular Model (SCM) is superior to ARIMA in this case.

Findings of the study are aligned with the literature. That is patterns of actual data and ARIMA forecasts are different. All the time domain analysis techniques or time series techniques assume the continuation of past patterns. If a forecasting

model is unable to capture the pattern of an actual series, then forecasts would be unreliable and inaccurate. Especially, such a model would be inappropriate in long term forecasting.

Share market indices may contain both seasonal and cyclical variations. The Cyclical variations are long term wave like patterns, while the seasonal variations are short term wave like patterns. Seasonal patterns are observed within a year, but the cyclical patterns are observed in longer period; at least more than a year. In general, Decomposition techniques are used to capture the cyclical patterns. In Decomposition models; a time series is described as a function of four components; Trend (*T*), Cyclical influence (*C*), Seasonal influence (*S*) and the random error (*e*). In order to capture the cyclical pattern, Decomposition technique follows several steps; firstly, fit the trend model and then obtain the de-trend series; secondly, find the seasonal indices for de-trended data and de-seasonalize them; finally model the de-seasonalized series by trigonometric functions. However, this method is time consuming and cumbersome. In contrast, the Sama Circular Model (CM) is easy to use and less time consuming.

Share market investments are exposed to two types of risks; systematic and unsystematic. Systematic risk depends on economy-wide uncertainties, such as the government changes, inflation, taxes etc. This part of the risk cannot be eliminated and all the investors are exposed to this. Unsystematic risk arises from the unique uncertainties of individual assets, such as strike in a company, labor turnover etc. This part of the risk can be reduced by diversification. In other words, unsystematic risk can be reduced by portfolio investments. Forecast in business sectors and individual companies of them can make portfolio selections easy and more profitable. As such it is recommended to test the SCM on forecasting sector indices and individual company returns of Bombay Stock Exchange.

REFERENCES

[1] Agrawal,, J. G., Chourasia, V. S., Mittra, A. K.,(2013). State of the Art in Stock Prediction Techniques. *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*. Vol. 2 (4).

[2] Ayodele A. A., Aderemi O. A., Charles K. A.,(2014). Comparison of ARIMA and Artificial Neural Networks Models for Stock Price Prediction. *Journal of Applied Mathematics*, 1-6. Retrieved from: http://dx.doi.org/ 10.1155/2014/614342

[3] Engle, R.F. (1982). Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation. *Econometrica*, 50(4), 987-1007.

[4] Emenike, K.O. (2010). Forecasting Nigerian Stock Exchange Returns: Evidence from autoregressive Integrated Moving Average (ARIMA) Model. *Department of Banking and Finance, University of Nigeria, Enugu Campus*, Enugu State, Nigeria, 2010. Retrieved from http://ssrn.com/abstract=1633006/

[5] Jayashree., S., (2014). A comparative study of BSE and international stock exchanges with special reference to pharmaceutical industries. *IOSR Journal of Business and Management (IOSR-JBM,)* 16(11), 22-40.

[6] Konarasinghe, W.G.S., Abeynayake, N.R., Gunaratne, L.H.P. (2015). ARIMA Models on Forecasting Sri Lankan Share Market Returns. *International Journal of Novel Research in Physics, Chemistry and Mathematics*, 2(1), 6-12. Available at: www.noveltyjournals.com

[7] Konarasinghe, W.G.S., (2016). Model Development for Stock Returns. *Doctor of Philosophy Thesis*, Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka

[8] Philippe, M. (2008). Analysis of Financial Time Series Using Fourier and Wavelet Methods. *Social Science Research Network (SSRN).* Retrieved from: http://ssrn.com/abstract=1289420

[9] Prapanna, M., Labani S., Saptarsi G. (2014). Study of Effectiveness of Time Series Modelling (ARIMA) in Forecasting Stock Prices. *International Journal of Computer Science, Engineering and Applications* (IJCSEA), .4(2), 13-29.

[10] Rosangela, B., Ivette L., Lilian M., Rodrigo, L. (2010).A comparative analysis of Eurofuzzy, ANN and ARIMA models for Brazilian stock index forecasting. Department of Economic Theory, Institute of Economics, University of Campinas, Brazil.

[11] Stephen, A., D., (1998). Forecasting Principles and Applications. First Edition. Irwin McGraw-Hill, USA.