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ARIMA Models on Forecasting Sri Lankan Share Market Returns

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Abstract: **Sri Lankan share market returns have wave like patterns. A wave can be viewed either in time domain or frequency domain. The time domain is a record of what happens to a parameter of the system versus time or space. Box-Jenkins methodology or Auto Regressive Integrated Moving Average (ARIMA) methodology was widely applied in explaining wave like patterns when wave is stationary type. This study was focused on testing ARIMA models on forecasting Sri Lankan share market returns. Stationary of the series were tested by Auto Correlation Functions and Partial Auto correlation Functions. ARIMA models were tested on total market returns, sector returns and individual company returns of Colombo Stock Exchange. Mean Square Error, Mean Absolute Deviation, residual plots and Anderson Darling test were used in model validation.**

Keywords: **ARIMA, Auto correlation, Fundamental analysis, Stationary, Technical analysis**

I. INTRODUCTION

Share market investment is considered as high return, but high risk investment. As such predictability of share returns in a secondary market is of immense importance to the investors. At one time share market forecasting was totally depend 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. A mathematical model is a simplification of a real world situation into an equation or a set of equations. 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 can be broadly classified into univariate statistical models and multivariate statistical 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. Univariate statistical modeling procedure is based on the past internal patterns in data to forecast the future and no external variables are required in forecasting. Auto Regressive Integrated Moving Average (ARIMA) method is a widely applied univariate forecasting technique in many fields (Stephen, 1998).

ARIMA methodology explained present value of a series (Y) by past values of Y itself and the stochastic error terms. According to Gujarati (2003), ARIMA model constitute a flexible class of models for describing the behavior of economic and financial time series. Various researchers have forecasted the behavior of financial time series using the ARIMA method. Some of the studies were: Rosangela, Ivette, Lilian and Rodrigo (2010), Rahman and Hossain (2006), Emenike (2010) and Jeffrey and Eric (2011).

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II. PROBLEM STATEMENT

Scientific forecasting in share market can be mainly divided in to two parts. They are fundamental analysis and technical analysis. Fundamental analysis involves analyzing the economic factors of a company while technical analysis interested in the price movements and / or trading volume in the market. Sri Lankan share market forecasting has been based on Capital Asset Pricing Model (CAPM), which is derived through fundamental analysis. But forecasting ability of CAPM has been debated over the last decades and studies based on many stock markets given evidence for the incapability of CAPM. Nimal (1997), Samarakoon (1997) and Konarasinghe and Abeynayake (2014-a) have given evidence for the same in Sri Lankan context. Therefore, Sri Lankan stock market is in need of finding suitable techniques for forecasting share returns.

Box-Jenkins (1976) methodology or the ARIMA methodology has also been widely tested for forecasting share returns, but such studies have been limited in the Sri Lankan context. However Konarasinghe and Abeynayake (2014-b) has shown that Sri Lankan share market returns are stationary type. Therefore ARIMA models may suitable in forecasting Sri Lankan stock market returns.

III. METHODOLOGY

ARIMA models are the most general class of models for forecasting a time series which is either stationary or can be made to be "stationary" by differencing. A time series is stationary if it has no trend, has constant mean and constant variance. The ARIMA forecasting equation for a stationary time series is a linear equation in which the predictors consist of lags of the dependent variable and/or lags of the forecast errors given by:

$$\phi_p(B)\Delta^d Y_t = \theta_q(B)\varepsilon_t \tag{1}$$

Where, Y_t = present value, ε_t : present error, B = backshift operator.

Listed companies of Colombo Stock Exchange (CSE) in year 2013 were the population of study. The population consist 20 business sectors. They were; Plantation (PLT), Oil palms (OIL), Land and Property (L&P), Motors (MTR), Manufacturing (MFG), Telecommunication (TLE), Stores supplies (S&S), Trading (TRD), Services (SRV), Power and energy (P&E), Investment trust (INV), Hotels and Travels (H&T), Heath care (HLT), Footwear and Textile (F&T), Information Technology (IT), Diversified Holdings (DIV), Construction and engineering (C&E), Chemicals and Pharmaceuticals (C&P), Beverage Food and Tobacco (BFT), Bank, Finance and Insurance (BFI).

ARIMA models were tested on total market returns, returns of random sample of four business sectors and random sample of 15 companies of CSE. Auto Correlation Functions (ACF) and Partial Autocorrelation Functions (PACF) were obtained to test the stationary of the series. When stationary was confirmed, several ARIMA models were tested on each series and best fitting model was selected by comparing MSE, MAD and results of goodness of fit tests.

Monthly All Share Price Index (ASPI) data, sector indices and daily closing share prices of individual companies from year 2003 to 2013 were obtained from CSE data library.

Total Market Return on month t, ($R_{,m,}$) was calculated by:

$$R_m = \left(\frac{ASPI_t - ASPI_{t-1}}{ASPI_{t-1}}\right).100 \tag{2}$$

Where, ASPI is All Share Price Index on month t.

$$R_S = \left(\frac{I_t - I_{t-1}}{I_{t-1}}\right).100 \tag{3}$$

Where, I_t is the sector index of the month t.

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Monthly average share prices were calculated for individual companies and monthly returns were calculated by formula:

$$R_t = \left(\frac{P_t - P_{t-1}}{P_{t-1}} \right).100 \quad (4)$$

Where P_t is the share price of month t

IV. STATISTICAL MODELS AND TECHNIQUES USED IN THE STUDY

Generalized Linear Models have been tested in the study. Histogram of residuals, normal plot of residuals and residuals versus fits were obtained to examine the goodness of model fit. In addition Anderson Darling test was used to test the normality of residuals. Forecasting ability of the models was assessed by two absolute measures of errors, Mean Square Error (MSE) and Mean Absolute Deviation (MAD).

Goodness of Fit Tests:

The goodness of fit of a statistical model describes how well it fits a set of observations. Measures of goodness of fit typically summarize the discrepancy between observed values and the values expected under the model in question. Residual plots; Histogram of residuals, Normal plot of residuals and residuals versus fits were obtained to examine the goodness of model fit. In addition Anderson Darling test is used for normality of residuals.

Measurements of Forecasting Errors:

Forecasting is a part of a larger process of planning, controlling and/ or optimization. Forecast is a point estimate, interval estimate or a probability estimate. One of the fundamental assumptions of statistical forecasting methods is that an actual value consists of forecast plus error; In other words, "Error = Actual value – Forecast". This error component is known as the residual. A good forecasting model should have a mean error of zero because it should over forecast and under forecast approximately the same (Stephen, 1998).

Measuring errors is vital in forecasting process. Measurements of errors are divided into two parts as absolute measures of errors and relative measures of errors.

V. FINDINGS

Data analysis consists three parts: test ARIMA on total market returns, test ARIMA on sector returns and test ARIMA on individual company returns. Data analysis was done by statistical software MINITAB.

Test Arima Models On Total Market Returns:

Out liars of the total market returns were removed from the data set by observing the box plot of data set. Figure 1 is the time series plot of out liar free total market returns.

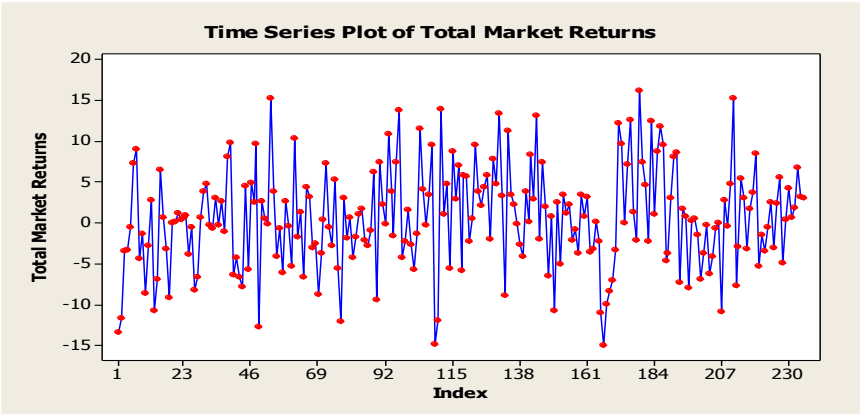

Fig. 1

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Fig. 1 shows a wave like pattern does not show any trend and suggests a stationary series. Therefore ACF (Fig. 2) and PACF (Fig. 3) of first difference series were obtained:

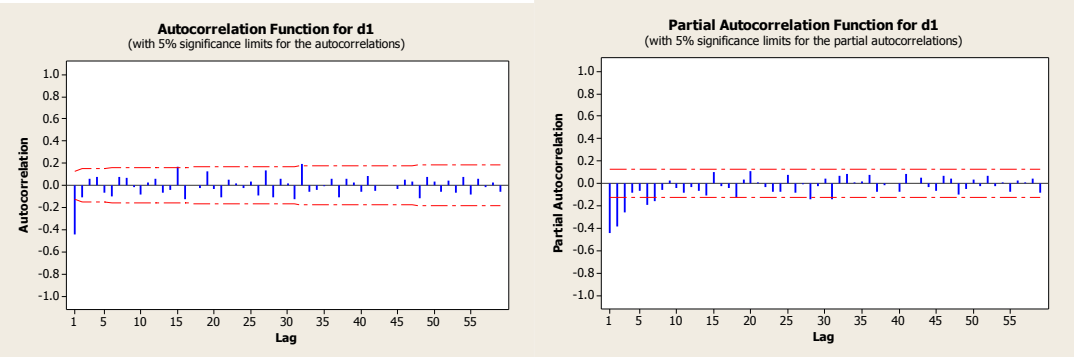

Fig. 2 **Fig. 3**

Fig.2 shows one significant spike at lag 1 and confirmed the stationary of the series. Fig. 2 shows decreasing pattern and confirm the same. Also above figures suggested the suitability of Auto Regressive (AR) models and Moving Average (MA) models. Hence several ARIMA models were tested and summary of results are given in Table I.

Table I

ARIMA Model	Model Fitting		Model Verification		Remarks
	MSE	MAD	MSE	MAD	
ARIMA (0,1,1)	35.81	4.66	77.89	7.20	Model parameters were significant. Residuals were normally distributed and uncorrelated
ARIMA (0,1,2)	36.76	4.69	77.72	7.19	MA 2 was not significant.
ARIMA (1,1,1)	34.79	4.58	73.33	6.93	AR 1 was not significant.

The goodness of fit of a statistical model describes how well it fits a set of observations. Measures of goodness of fit typically summarize the discrepancy between observed values and the values expected under the model in question. Residual plots; Histogram of residuals, Normal plot of residuals and residuals versus fits were obtained to examine the goodness of model fit. In addition Anderson Darling test was used for normality of residuals. Figure 4 is the residual plots of ARIMA (0, 1, 1):

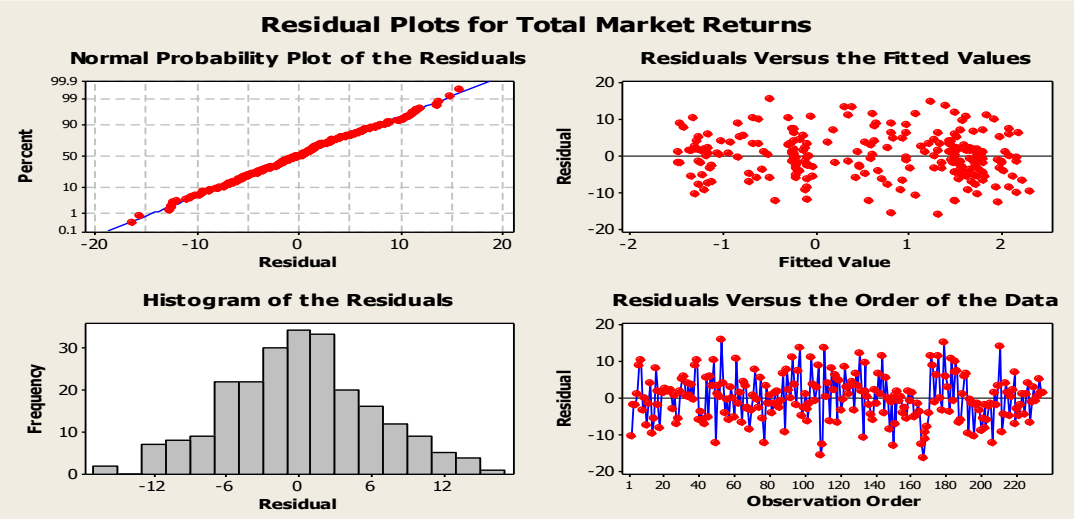

Fig. 4

In Normal Probability Plot of Residuals, almost all the points were on a straight line. Histogram of Residuals was symmetrical. Also p value of Anderson Darling test (0.581) was greater than the significance level (0.05). Therefore it was concluded that the residuals of the model are normally distributed. Plot of Residual Vs Fitted Values did not show any pattern and they lie on both sides of zero. It suggests the independence of residuals. Modified Box-Pierce (Ljung-Box) Chi-Square statistic was greater than significance level (0.05), confirmed the independence of residuals. Hence ARIMA (0, 1, 1) is the best fitting model for forecasting total market returns of CSE.

Same procedure was repeated with sector returns and individual company returns. Table II gives the summary of outputs of sector returns and Table 3 gives the summary of outputs of individual company returns.

Table II: Best Fitting ARIMA Models for Sector returns

Business Sector	Best Fitting ARIMA Model	Model Fitting		Model Verification		Remarks of residuals
		MSE	MAD	MSE	MAD	
Sector DIV	ARIMA (0,1,1)	51.35	5.40	44.58	5.00	Normal, uncorrelated
Sector L&P	ARIMA (0,1,1)	73.42	6.79	62.04	5.96	Normal, uncorrelated
Sector MFG	ARIMA (0,1,1)	45.14	5.14	73.83	6.67	Normal, uncorrelated
Sector MTR	ARIMA (0,1,1)	63.02	6.14	63.80	6.31	Normal, uncorrelated

MAD of all the models was satisfactory in both model fitting and model verification, but MSE's of the models were high. Still residuals of all the models were normally distributed and uncorrelated. Therefore ARIMA (0, 1, 1) are the best fitting models for all the four sectors.

Table III: Best Fitting ARIMA Models for Individual Company returns

Company	Best Fitting ARIMA Model	Model Fitting		Model Verification		Remarks of residuals
		MSE	MAD	MSE	MAD	
COMBANK	ARIMA (0,0,1)	55.27	6.00	68.96	6.26	Normal, uncorrelated
HNB	ARIMA (0,1,1)	36.92	4.63	37.11	5.0	Not normal, uncorrelated
BREW	ARIMA (0,0,1)	31.24	4.45	37.97	5.03	Normal, uncorrelated
LMF	ARIMA (0,1,1)	0.48	0.54	0.64	0.64	Normal, uncorrelated
AGAL	ARIMA (0,1,1)	0.028	0.58	1.43	0.87	Normal, uncorrelated
BOGA	ARIMA (0,1,1)	0.68	0.65	1.61	0.93	Normal, uncorrelated
WATA	ARIMA (0,1,1)	0.55	0.11	1.75	1.01	Normal, uncorrelated
JKH	ARIMA (0,1,1)	83.8	7.27	72.59	6.89	Normal, uncorrelated

DIAL	ARIMA (0,0,1)	36.61	4.84	50.26	5.08	Normal, uncorrelated
CIC	ARIMA (0,1,1)	51.87	5.61	66.08	6.48	Normal, uncorrelated
HAYL	ARIMA (0,0,1)	54.7	5.71	69.69	6.95	Normal, uncorrelated
GALAD	ARIMA (0,1,1)	0.35	0.45	0.56	0.43	Not normal, uncorrelated
TWOD	ARIMA (0,1,1)	0.73	0.63	0.61	0.62	Not normal, uncorrelated
TAJ	ARIMA (0,1,1)	0.25	0.39	0.20	0.37	Normal, uncorrelated
RICH	ARIMA (0,1,1)	54.63	5.69	96.77	7.99	Normal, uncorrelated

MAD of all the models was satisfactory in both model fitting and model verification, but MSE's of the models were high in some models. Residuals of all the models were normally distributed and uncorrelated. ARIMA (0, 1, 1) is suitable for forecasting returns of 12 companies and ARIMA (0, 1, 1) suitable for forecasting returns of the other 3 companies.

According to the results, ARIMA (0, 1, 1) model:

$$Y_t = Y_{t-1} + \mu + \varepsilon + \theta\varepsilon_{t-1} \quad (5)$$

is the best fitting model for forecasting Sri Lankan stock market returns.

VI. CONCLUSION

Share trading is an important part of the economy of a country from both the industry's point of view as well as the investor's point of view. For example, whenever a company wants to raise funds for further expansion or settling up a new business venture, instead of taking loans it can issue shares of the company. On the other hand an investor can get the part ownership of the company through buying shares. Also investors have the ability to quickly and easily sell securities. But Share market investment is involved with high risk, compared to the other forms of investment such as investment in real estate, treasury bills etc. Therefore forecasting share returns were immensely important to the investors.

Scientific forecasting in share market returns based on two main categories: fundamental analysis or technical analysis. Forecasting Sri Lankan share market returns has been based on fundamental analysis, but has been proved unreliable. As such it is essential to find a suitable forecasting technique for Sri Lankan share market.

ARIMA models have been successfully used in forecasting economic time series; however such studies were limited in Sri Lankan context. This study was focused on testing ARIMA models in forecasting Sri Lankan share market returns. Stationary of total market returns, sector returns and individual company returns were confirmed by ACF's and PACF's. Based on the results, it was concluded that ARIMA models are suitable in forecasting Sri Lankan stock market returns.

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