JOHN ERWIN B. ARANAS **TIME SERIES ANALYSIS**

STUDENT PROJECT **FALL 2015**

INTRODUCTION:

The Philippine economy has been in the radar of investors since the Aquino Administration took office on July 2010. An article in Wallstreetdaily.com, last July 2, 2015, even called the Philippines a Safe Haven for Investors. It said that, as other governments around the world have been running in huge budget deficits, the Philippines runs a balanced budget and even posted a rapid growth in the economy with an average of 6.3% annually from 2010 to 2014.

Credit rating as well has been recorded the highest in the country's history. It was on March 27, 2013 when the Philippines was first rated an investment grade BBB- from Fitch. S&P also granted the Philippines a credit rating which is a notch higher than the minimum investment grade BBB on May 2, 2013.

PSE Index also has been on record high as it breached for the first time the 7,000 mark on April 22, 2013.

For this project, I will illustrate the Box-Jenkins Method in time series modeling the PSE Index (PSEI). The data time series is from November 2, 2011 to January 22, 2016 and use the last price as our time series.

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METHODOLOGY:

Stock prices generally follow a geometric Brownian motion. Log-transformation will be applied to the data and serve as our observed time series.

We will investigate the ACF and PACF to decide on data differencing and to nominate ARIMA models. We will compare all models and choose which the best among those nominated is. It is worthy to note that the best among those nominated is not necessarily the correct/appropriate model to represent the observed time series. The Box-Jenkins method is a cycle in which we nominate models and review results until we satisfied generally accepted measures of reliability.

The nomination of ARIMA models will be based on Exhibit 6.3, (Chapter 6, page 116) of the Time Series Analysis (Second Edition) book of Jonathan D. Cryer and Kung-Sik Chan. The said table is replicated below:

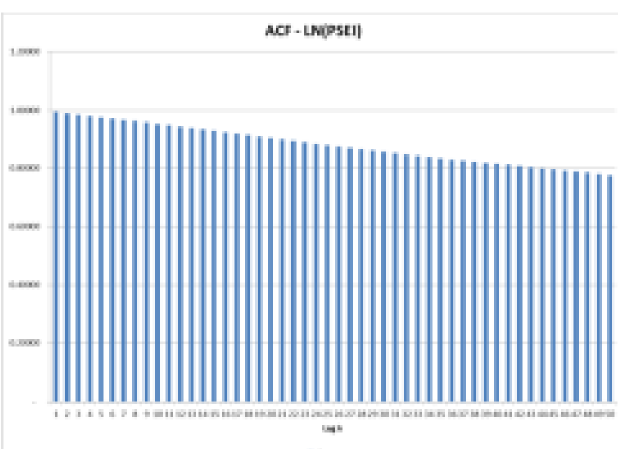
<u>Exhibit 6.3 General Behavior of the ACF and PACF for ARMA Models</u>

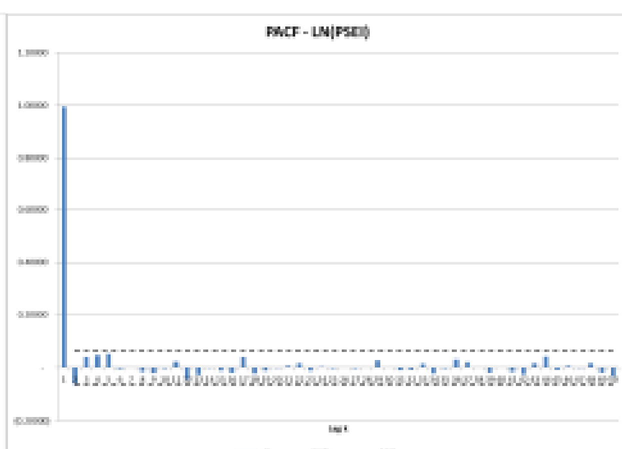
	AR(p)	MA(q)	ARMA(p,q), p>0 and q>0
ACF	Tails off	Cuts off after lag q	Tails off
PACF	Cuts off after lag p	Tails off	Tails off

We will then estimate the ARIMA parameters using method of moments and proceed to residual analysis in comparing which model is appropriate for the observed time series. That is, by looking at standardized residual plots and residual q-q plots.

RESULTS AND DISCUSSION:

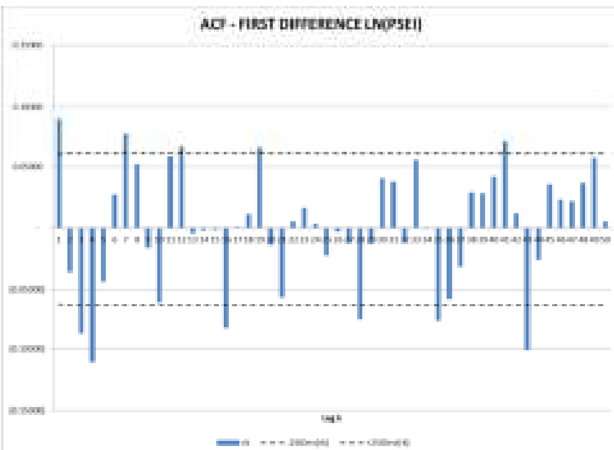
The graphs ACF and PACF of the observed time series are as follows:

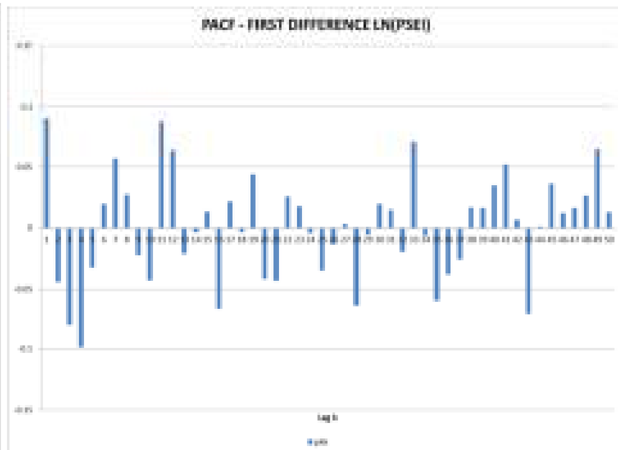




The ACF tails off and the PACF cuts off at lag 1. Based on Exhibit 6.3, this suggest that we can model the observed time series using AR(1) model. Proceeding to estimate $\hat{\phi} = r_1 \approx 1$ means that we have a unit-root thus the resulting AR(1) model is non-stationary. This leads us to take the first difference of the observed time series.

The graphs of ACF and PACF of the first difference of the observed time series are as follows:



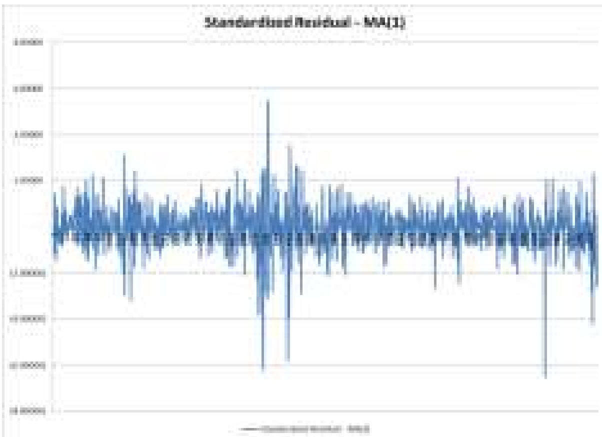


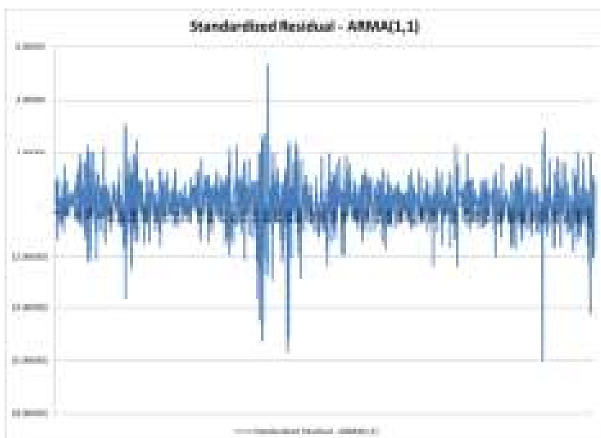
Both the ACF and PACF cuts off at lag 1 and seems to show sine wave. Based on Exhibit 6.3, the ACF suggests an MA(1) model while the PACF suggests and AR(1) model. Since looking at the graphs both at the same time does not suggest any model based on Exhibit 6.3, I will consider the combination of the suggested models of the ACF and the PACF which is an ARMA(1,1) model.

Estimating parameters using method of moments we arrived at the following:

ARIMA Model	$\hat{\theta}_1$	$\hat{\phi}_1$
MA(1)	-0.09118	N/A
AR(1)	N/A	0.09043
ARMA(1,1)	-0.71801	-0.39649

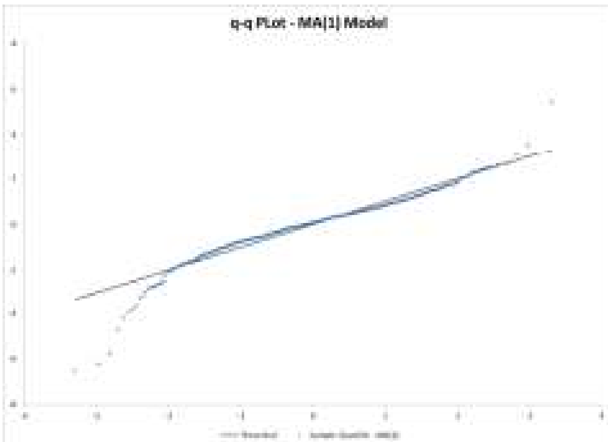
The graphs of standardized residuals are illustrated below:

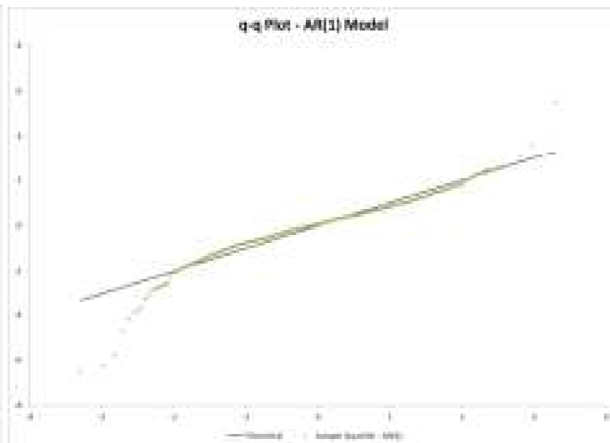


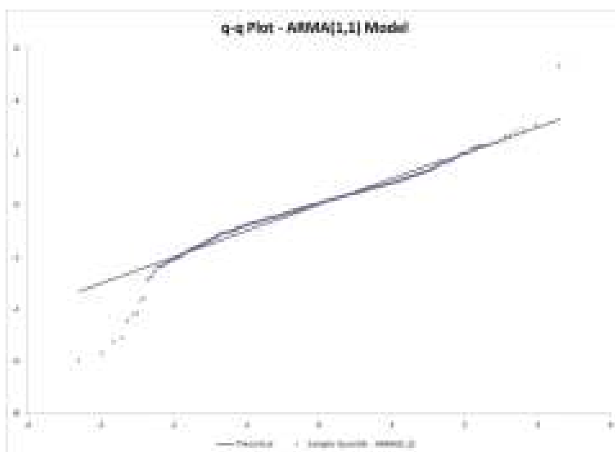


All three of them seem to have non-zero mean and a constant variance. It is worth nothing that there are outliers seen in the standardized residual plots. Values which are beyond ± 3. The modeling of outliers is recommended but we will not pursue it here. We proceed at comparing the individual q-q plots.

The q-q plots are illustrated below:







Based on the q-q plots, all are thick-tailed compared to the standardized normal curved. Among the three nominated models, it is the ARMA(1,1) model which is best. Among the three, it is the closest to normal when comparing extreme values.

That is, we choose to model the first difference of the observed series by:

$$\Delta lnY_t = -0.39649\Delta lnY_{t-1} + e_t + 0.71801e_{t-1}$$

CONCLUSION:

The Box-Jenkins method is a very useful tool in modeling a time-series data. As illustrated, this works by nominating and reviewing results until we satisfy generally accepted measures of reliability. In this exercise, we used the standardized residual plots and the q-q plots. Interested researchers may further improve the modeling by using other method of model nomination such as the Extended Autocorrelation Function, other method of parameter estimation such as the Least-squares and Maximum likelihood, and by analyzing other measures such as the Ljung-Box statistic and the AIC and BIC statistic. Most of this can be performed using the statistical software R.

DATA SOURCE:

PSEI historical prices - http://www.investing.com/indices/psei-composite-historical-data

The Philippines: A Safe Haven for Investors - http://www.wallstreetdaily.com/2015/07/02/philippines-income-investing/

Philippine Credit Ratings - http://www.gov.ph/report/credit-ratings/

Stock Pierce 7,000 barrier - http://bworldonline.com/content.php?section=StockMarket&title=Stocks-breach-7,000-territory-by-noon&id=69033