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A UNIVARIATE ESTIMATION OF THE PHILIPPINE'S EXCHANGE RATE

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ABSTRACT

This study aims to forecast the Exchange Rate of the Philippines for five years starting from 2016 to 2020, and determine which among Inflation Rate, Purchasing Power of Peso, Interest Rate, Exports, Imports, and Balance of Payments is a significant factor that can influence Exchange Rate. The researchers used the monthly data of the variables starting from January 1999 to December 2015, which were gathered from Bangko Sentral ng Pilipinas with a total of 204 observations. In forecasting the dependent variable, the researchers used the Box-Jenkins Methodology. The researchers also examined the relationship between the variables using the Pairwise Granger Causality Testand Johansen Cointegration Test. Stepwise Multiple Linear Regression was also performed to determine the significant factors that can actually predict the Exchange Rate.

Keywords: Box-Jenkins Methodology; Exchange Rate; GrangerCausuality; Paired t-test; Johansen Cointegration Test; Regression.

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1. INTRODUCTION

Peso, the Philippine currency has shown fluxes for the past decades when being exchanged in foreign currencies especially in dollars. In 1962, peso started its value from P2 to P3.90 per dollar. By February 1970, the exchange rate was set by the forex market until it settled to 6.94 pesos per dollar [1]. During Corazon Aquino's term, the power crisis and coup d'état caused the exchange rate to weaken against dollar. This weakening of peso continues to Joseph Estrada's administration following the 1997 to 1998 Asian Financial Crisis where peso drops to 43.68 pesos. When Gloria Arroyo sat as the president of the Philippines, the exchange rate had become 56.37 pesos per dollar due to many political divisions that put Arroyo's leadership to question. Just then when Benigno Aquino III was elected when peso started to appreciate, and the foreign exchange was recorded to be 43.30 pesos per dollar [2].

An appreciated currency is more valuable because it means that it can buy more foreign goods and services that are denominated in foreign currency. This indicates that importing products from other country will be less expensive, and it also makes domestic products more expensive when exported [3].

Since the exchange rate serves as the basic link between the local and the foreign markets for several products, services, and financial assets, fluctuations in the Philippines' exchange rate can cause disturbances in domestic prices of imported goods and services, costs of servicing on foreign debt, and the country's external sector through its impact on foreign trade [4].

At present, the country's exchange rate policy supports a freely floating exchange rate system whereby the Bangko Sentral ng Pilipinas (BSP) leaves the determination of the exchange rate to market forces. BSP allows the value of the peso to be determined by the supply and demand of foreign exchange [4].

Exchange rate must be monitored regularly, and must sustain its stability because a small change in the currency has a large effect in the economy of the country. This paper will support the government in analyzing the conditions of the country's exchange rate to be able to formulate effective policies which can maintain the peso in the foreign exchange market. This study may aid them in creating monetary and fiscal policies.

The researchers aims to forecast the Exchange Rate of the Philippines for the next five years starting from 2016 to 2020. The forecasted and predicted values of Exchange Rate is to be obtained using Box-Jenkins Method. Significant factors of the Exchange Rate are also to be determined among the following determinants: Inflation Rate, Purchasing Power of Peso, Interest Rate, Exports, Imports, and Balance of Payments using Stepwise Multiple Linear Regression. This paper will help the government in monitoring the Exchange Rate, and implementing measures to maintain the order and stability in the foreign exchange market.

1.1.Research Paradigm

In order to accomplish the objective of the study, the researches follow a research paradigm which includes the inputs and processes to be used, at the same time the expected outputs. Monthly data of the variables are used as the inputs of this paper.

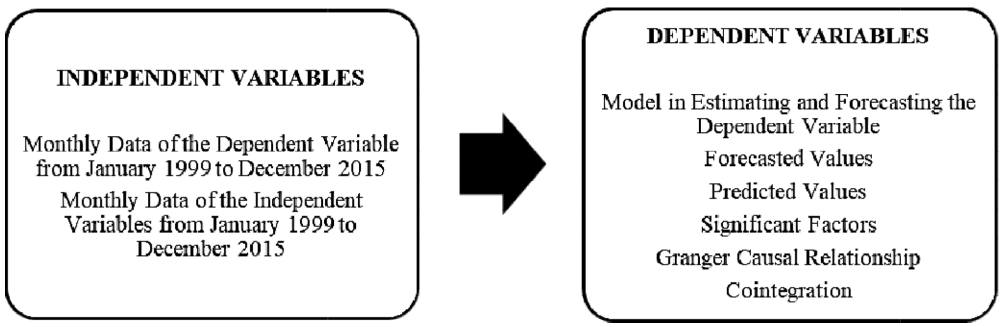

Fig.1. Research paradigm

Applying the Box-Jenkins Methodology, the researchers aim to formulate the model in estimating and predicting the inputs specifically the dependent variable. Stepwise Multiple Linear Regression is used to obtain the significant factors that can affect the dependent variable. At the same time, the researchers examine the granger causal relationship and the cointegration between the dependent and independent variables using Pairwise Granger Causality Test and Johansen Cointegration Test, respectively.

1.2 Statement of the Problem

This study aims to formulate a mathematical model that can actually estimate and forecast the Exchange Rate of the Philippines. Specifically, the researchers aim to answer the following questions:

1. What is the behavior of the graph of the following variables?
    a. Exchange Rate
    b. Inflation Rate
    c. Purchasing Power of Peso (PPP)

d. Interest Rate

e. Exports

f. Imports

g. Balance of Payments

2. What are the significant factors that can actually estimate the Exchange Rate of the Philippines using Stepwise Multiple Linear Regression?
3. What is the mathematical model in forecasting and estimating the Exchange Rate of the Philippines using Autoregressive Integrated Moving Average (ARIMA) modeling?
4. Is there a significant difference between the actual and predicted values of Exchange Rate?
5. Is there a cointegration between the Dependent and Independent Variables?
6. Is there a granger causal relation between the Dependent and Independent Variables?

1.3 Scope and Limitation

The researchers used the monthly data of the variables starting from January 1999 to December 2015, which were gathered from Bangko Sentral ng Pilipinas with a total of 204 observations. The variables include the Exchange Rate, Inflation Rate, Purchasing Power of Peso, Interest Rate, Exports, Imports, and Balance of Payments.

2. METHODOLOGY

2.1 Multiple Linear Regression

Multiple linear regression is the most common form of linear regression analysis. It is a statistical technique for estimating the relationship among variables which have reason and result relation. The general form of multiple linear regression is defined as:

$$\hat{y} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_p x_p + \varepsilon \quad (1)$$

where $\hat{y}$ is the predicted values of the dependent variable, $X$is the independent variable, $\beta$is the parameter, and ε is the error [5].

2.1.1 Stepwise Multiple Linear Regression

Stepwise Multiple Linear Regression is a semi-automated process of building a model by successively adding or removing variables based solely on the t-statistics of their estimated coefficients. The stepwise option lets you either begin with no variables in the model or proceed forward (adding one variable at a time), or start with all potential variables in the model and proceed backward (removing one variable at a time) [6].

2.2 Johansen Cointegration Test

Cointegration means that, while many developments can cause permanent changes in the individual variable, there is some long-run equilibrium relation tying the individual variables together, represented by some linear combination of them. The Johansen test makes it possible to estimate all cointegrating vectors when there are more than two variables [7].

2.3 Granger Causality Test

Granger causality is a statistical test to determine if one variable is an indicator over a period of time. It is assumed that the relationship between variables remains stable. A variable x is said to Granger-cause y if the prediction of the current value of y is enhanced by using the past values of x[8]. Granger causality tests are typically implemented through bivariate regressions:

$$Y_t = \prod_{11} Y_{t-1} + \prod_{12} X_{t-1} + \upsilon_{1t} \tag{2}$$

where the Π_{ij} are parameters, and the υ_{it} are the random error terms. X_t is said to Granger causes Y_{t+1} if $\Pi_{12} \neq 0$, and Y_t Granger causes X_{t+1} if $\Pi_{21} \neq 0$ [9].

2.4 Autoregressive Integrated Moving Average

The ARIMA procedure analyzes and forecasts equally spaced univariate time series data, transfer function data, and intervention data using the Autoregressive Integrated Moving-Average (ARIMA). An ARIMA model predicts a value in a response time series as a linear combination of its own past values, past errors and current and past values of other time series. In terms of y, the general forecasting equation is:

$$\hat{y}_t = \mu + \phi_1 y_{t-1} - \theta_1 e_{t-1} \tag{3}$$

where $\hat{y}$ is the forecasted values of the dependent variable, t is the time index, μ is the intercept, ϕ is the autoregressive operator, and θ is the moving average operator [10].

2.5 Box-Jenkins Methodology

Box-Jenkins Methodis a process of formulating a mathematical model which requires at least a moderately long time series for an effective model fitting, and generally include autoregressive, moving average, and seasonal moving average terms, as well as difference and seasonal difference operators. There are three stages in building a Box-Jenkins model [11]:

1. Model Identification. This stage includes the following steps:
   a. Detecting the stationarity of the series.
   b. Detecting the seasonality of the series.
   c. Identifying the order of the autoregressive and moving average terms.
2. Model Estimation. The main approaches in estimating the parameters using Box-Jenkins method are the non-linear least squares and the maximum likelihood estimation.
3. Model Validation. The model must undergo diagnostic checking by satisfying the assumptions that the residuals should be independent when their distribution are normal.

2.5.1 Augmented Dickey-Fuller Test

Augmented-Dickey Fuller test is used to determine whether a unit root, a feature that can cause issues in statistical inference, is present in an autoregressive model. It is the simplest approach to test for a unit root. Given an observed time series $Y_1, Y_2 \ldots Yn$, Dickey and Fuller consider a differential-form autoregressive equations to detect the presence of a unit root [12]:

$$\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{j=1}^{p} \left(\delta_j \Delta Y_{t-j} \right) + e_t \tag{4}$$

where t is the time index, α is an intercept constant, β is the coefficient on a time trend, γ is the coefficient presenting process root, p is the lag order of the first-differences autoregressive process, and e_t is an independent identically distributes residual term.

2.5.2 Correlogram

Correlogram is also called as Autocorrelation Function or Serial Correlation Function. It is a graph, at the same time, a statistical procedure for the analysis of time series data and to test for the presence of cyclic phenomena [13]. ACF is written as:

$$r_k = \frac{\sum_{t=1}^{n-k} (y_t - \bar{y})(y_{t+k} - \bar{y})}{\sum_{t=1}^{n} (y_t - \bar{y})^2} \tag{5}$$

where r_k is the autocorrelation coefficient, t is the observations, and $\bar{y}$ is the mean.

2.5.3 Paired T-test

A paired t-test is used to compare two population means where you have two samples in which observations in one sample can be paired with observations in the other sample. It is written as [14]:

$$t = \frac{\bar{y} - \mu}{\frac{\sigma}{\sqrt{n}}} \tag{6}$$

where $\bar{y}$ is the mean, μ is the hypothesized difference, σ is the standard deviation, and n is the sample size.

3. RESULTS AND DISCUSSION

3.1 Behavior of the Graph

The graph of exchange rate from January 1999 to December 2015 exhibits a fluctuating downward trend indicating that the value of peso against foreign currencies has been increasing for the past decade. In October 2004, the lowest value of peso was recorded as it drops to P56.34 to the dollar, yet it reached its peak of P37.83 to the dollar in May 1999 due to the several global crisis that weakened the dollar and other major currencies [15].

Inflation rate has been decreasing for the past 16 years. Its graph reveals a descending trend with fluctuating patterns. In January 1999, the Philippines has experienced the highest inflation of 10.7 % within the year 1999 to 2015 because the agriculture supply declined and could not cope with the existing demand for food but dropped to 0.4 percent in September 2015 according to the PIDS or Philippines Institute for Development Studies [16].

Purchasing Power of Peso shows a downward trend from 1999 to 2015 with minimal changes by the year of 2012. The highest value of peso was recorded way back April 1999 with 1.05 % due to weakening of foremost currencies during the Global Financial Crisis then takes back on November 2011 with 0.57 % [15].

Interest rate has been revealing a downward movement with major fluctuations in the year 2002 to 2008 before having a constant rate from 2009 until 2015. It has been recorded with the uppermost rate of 9.5 % in December 2000 due to worries over the impact of the US subprime mortgage market troubles on local markets. On the other side, a rate of 3.25 % was noted in January 2009 for the domestic interest rates in the primary market declined significantly due to strong demand for government securities on the back of the country [17].

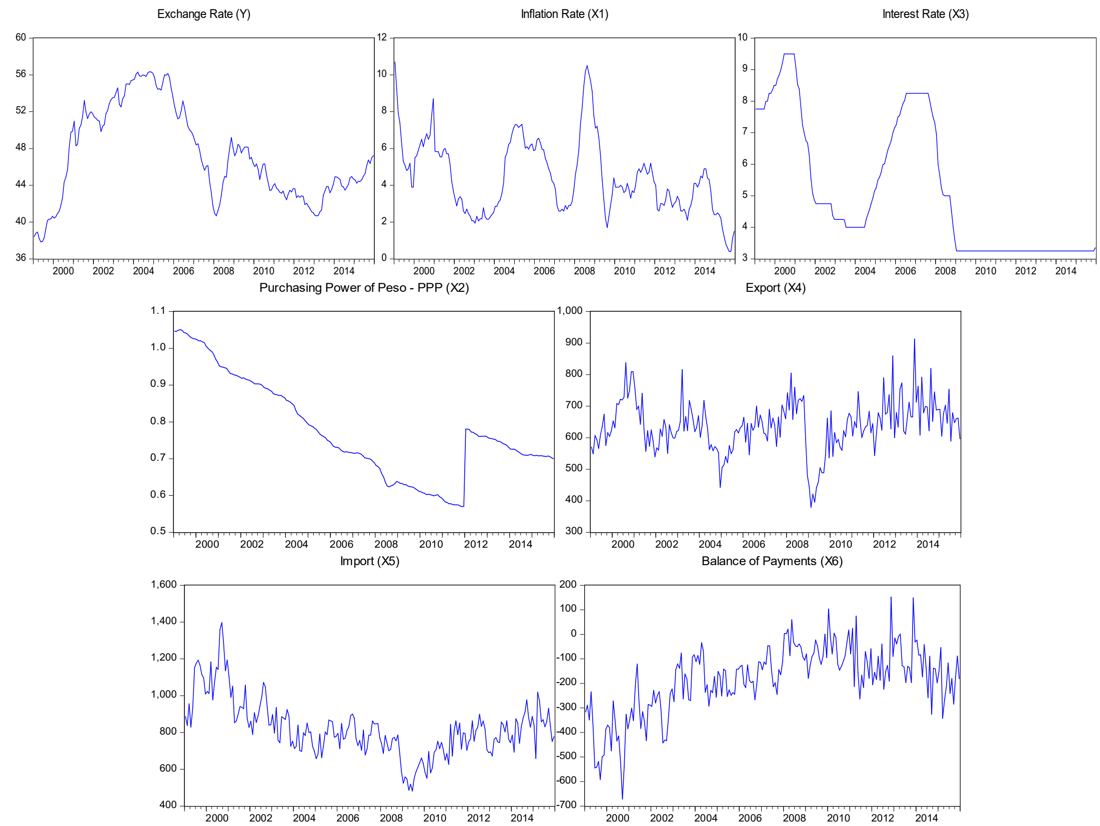

Fig.2. Graph of the variables

For the past 16 years, exports have been showing an upward trend with fluctuating trends. In November 2013, exports in the Philippines was noted to be 912.8 million by the National Economic and Development Authority (NEDA) attributed to the quadrupling of coconut oil exports [18]. However, in February 2009, exports is only 379.1 million based on the records.

From 1999 to 2015, imports exhibits a downward trend with fluctuating patterns. Imports reached 1397.3 million in September 2000 but it dropped in June 2009 to 481.5 million as semiconductor shipments contracted almost 40 percent to signal tougher days ahead for one of Asia's fastest-growing economies [19].

From year 1999 to 2015, balance of payments has been increasing from time to time. In September 2000, it was noted the lowest of -671.8 and the highest of 152.5 in November 2012 as aid money from abroad to finance reconstruction efforts in central Philippines enters the country [20].

3.2 Significant Factors

Using Stepwise Multiple Linear Regression, the researchers are able to determine the significant factors that can actually estimate the Exchange Rate. Among the six independent variables namely Inflation Rate, Purchasing Power of Peso, Interest Rate, Exports, Imports, and Balance of Payments, only two are considered as significant factors of the dependent variable based on the result of the regression analysis.

Table 1. Regression analysis

Variables	p-value
Inflation Rate (x_1)	0.469
Purchasing Power of Peso (x_2)	0.010
Interest Rate (x_3)	0.353
Exports (x_4)	0.000
Imports (x_5)	0.052
Balance of Payments (x_6)	0.019

With a level of significance of 0.01, Purchasing Power of Peso and Exports are found out to be the significant factors of Exchange Rate having a p-value of 0.010 and 0.000 respectively.

3.3 ARIMA Model

Autocorrelation shows no patterns indicating that there is no seasonality in the data series. To attain stationarity, the researchers differenced the data. Stationarity was achieved at the first difference. The correlogram of the differenced logarithmic Exchange Rate is used in formulating possible combinations of AR and MA terms to come up with the model in forecasting and estimating the data.

To be able to come up with the best fitted model, the researchers identify the significant spikes in the correlogram of the differenced logarithmic Exchange Rate. Out of the eight model candidates, AR(1) MA(1) MA(6) MA(18) is considered as the best fitted model. The order of the autoregressive terms and moving average terms is written as ARIMA (1,1,3) with the model having one AR term, being differenced once, and having three MA terms.

The chosen model in forecasting and estimating the Exchange Rate has an R-squared of 0.9844, a Durbin-Watson statistics of 1.9348, a Mean Absolute Error of 0.4790, an Akaike Information Criterion of 1.9736, and a Breusch-Pagan-Godfrey p-value of 0.0802. This indicates that the model is good enough in estimating the Exchange Rate because errors are uncorrelated, and the variances are equal.

3.4 Predicted Values

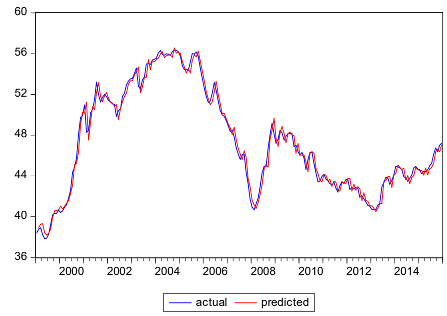

Fig.3. Graph of the actual and predicted values of exchange rate

The researchers concluded that there is no significant difference between the actual and predicted values of Exchange Rate. The null hypothesis of no significant difference was accepted based on the result of the Paired T-test having a p-value of 0.99.

3.5 Cointegration

Using Johansen Cointegration Test which includes Trace test and Maximum Eigenvalue test, the cointegration among the variables are identified. It is found that there exist a cointegration between the Exchange Rate and Inflation Rate, Purchasing Power of Peso, Exports, Imports, and Balance of Payments having a p-value less than 0.05.

Table 2. Cointegration

Variables	p-value
Inflation Rate (x_1)	0.0250
Purchasing Power of Peso (x_2)	0.0294
Interest Rate (x_3)	0.1887
Exports (x_4)	0.0112
Imports (x_5)	0.0259
Balance of Payments (x_6)	0.0457

Trace test and Maximum Eigenvalue test show that the null hypothesis is rejected either at none or at most 1 except for Interest Rate that shows no cointegration to Exchange Rate.

3.6 Granger Causal Relationship

Granger causality tells whether a variable affects the other one. Using the Pairwise Granger Causality test, the researchers are able to determine which among the independent variables can really affect the Exchange Rate.

Table 3. Granger Causality Test

Null Hypothesis	p-value
Inflation Rate (x_1) does not Granger Cause Exchange Rate (y)	0.0414
Purchasing Power of Peso (x_2) does not Granger Cause Exchange Rate (y)	0.0028
Interest Rate (x_3) does not Granger Cause Exchange Rate (y)	0.5874
Exports (x_4) does not Granger Cause Exchange Rate (y)	0.0659
Imports (x_5) does not Granger Cause Exchange Rate (y)	0.0007
Balance of Payments (x_6) does not Granger Cause Exchange Rate (y)	0.0084

Based on the results obtained, Purchasing Power of Peso, Imports, and Balance of Payments are the factors that have a granger causal relationship with Exchange Rate having a p-value of 0.0028, 0.0007, and 0.0084, correspondingly, rejecting the null hypothesis of there is no granger causality between the two variables.

4. CONCLUSION

Exchange rate of the Philippines since 1999 to 2015 exhibits a downward trend implicating that the value of peso has been increasing for the past decades. After analyzing and examining the data series, the researchers are able to come up with the model ARIMA (1,1,3) which is considered as the best fitted model among the possible combinations created. A five-year forecast of the exchange rate was conducted using the model from year 2016 to 2020 following the trend of the data series. Additionally, Paired T-test shows that the predicted values obtained using the model is 99 percent identical to the actual values of exchange rate. Among the six independent variables, Purchasing Power of Peso and Exports are found to be the significant factors of Exchange Rate obtained using Stepwise Multiple Linear Regression. It is also found out that five of the independent variables have a long run relationship with the dependent variable based on Johansen Cointegration test, except for Interest Rate. Moreover, Purchasing Power of Peso, Imports, and Balance of Payments appears to have a granger causal relationship with Exchange Rate. This research will be of help to BSP especially in monitoring the exchange rate in the foreign market.

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