

An Analytical Study On Forecasting Exchange Rate In The Philippines Using Multi-Layer Feed Forward Neural Network

Jackie D. Urrutia^{a,b}, Gerald O. Bariga^c, Julius Christian M. Putong^d

^aResearch Management Office, Polytechnic University of the Philippines

^bDepartment of Mathematics and Statistics, College of Science, Polytechnic University of the Philippines

^cTransaction Processing New Associate, Accenture

^dDesktop Reseracher, Reed Elsevier Philippines

Corresponding Email: ^ajackieurrutia20@gmail.com / math_urrutia@yahoo.com.ph

Article History: Received: 10 November 2020; Revised 12 January 2021 Accepted: 27 January 2021; Published online: 5 April 2021

Abstract: Exchange Rate is one of the economic indicators in the Philippines. It is the value of the nation's currency versus the currency of another country or economic zone. This study aims to forecast the monthly Exchange Rate (y) of the Philippines from November 2018 to December 2023 using Multiple Linear Regression and Multi-Layer Feed Forward Neural Network. The researchers investigate the behaviour of each independent variables – Inflation Rate (x1), Balance of Payments (x2), Interest Rate (x3), Producer's Price Index (x4), Export (x5), Import (x6), Money Supply (x7), and Consumer's Price Index (x8) from Philippine Statistics Authority (PSA) starts from January 2007 up to October 2018. Multiple Linear Regression (MLR) was used to identify significant predictors among these independent variables. The Exchange Rate (y) had undergone first difference transformation. Upon running the regression analysis, it has concluded that only two independent variables are significant predictors, namely: Balance of Payments (x2) and Import (x6). Through these significant predictors, the MLR model was formulated. On the other hand, Multi-Layer Feed forward Neural Network (MFFNN) was also used to determine the forecasted values of Exchange Rate (y) for the next five years (2018-2023) given the said independent variables and obtained a model. The researchers compared the model of Multiple Linear Regression and Multi-Layer Feed Forward Neural Network by evaluating the forecasting accuracy of each method. It was concluded that Multi-Layer Feed forward Neural Network is the best fitting model for forecasting the

Exchange rate (y) in the Philippines. This paper will serve as a tool of awareness for the government to foresee the trend of Exchange Rate in the Philippines on the next five years (2018-2023) for Monetary Policy making and to prevent the possible depreciation of peso vs. dollar..

Keywords: Multiple Linear Regression, Multi-Layer Feed Forward Neural Network, Exchange Rate, and Forecasting Accuracy

1. Introduction

Exchange rate is the charge of a unit of overseas foreign money in phrases of the home currency. The trading rate in Philippines is expressed as the value of US dollar into peso equivalent. It acts as the main connection between the local and the other country's market for more than a few goods, services and financial assets. Through this, we had been able to determine expenses of goods, services, and assets quoted in exclusive currencies. In 2007, Philippine peso advanced 19.5 percent to the dollar because of a sudden rise of interest rate and the falling off of inflation which was regarded as Asia's best performing currency [2] It is anticipated that this will continually to foster in the next year (2008) wherein the analysts forecasted that the exchange rate will hit P38: US\$1, or up to P35:US\$1. In contradiction, the government expected is more conventional at P40-P46:\$1. [3] However, in 2018 the Philippine peso denotes its weakest execution more than 13 years as it achieved 53.8 peso to 1 dollar. [4] The depreciation was due to the merging of external and domestic shocks amid surging inflation. [5] Due to the level of difficulty and sensible applications for forecasting exchange rate, it became an important monetary problem. The artificial neural network (ANN) have been extensively used as an another method for forecasting undertakings because of its various unique features. This method was widely used in every research of forecasting exchange rate. . [6] There is wide diversity of factors that influence Exchange Rate nonetheless the researchers considered eight (8) expository variables. These are : Inflation Rate (x1), Balance of Payments (x2),

Interest Rate (x_3), Producer Price Index(x_4), Export (x_5), Import (x_6), Money Supply (x_7), and Consumer's Price Index (x_8). This study will be a guide to the nonstop deterioration of Exchange Rate(y) in the Philippines so as to know which factor the government should focus on for improvement..

1.1.Objective of the Study

The researchers aim to scrutinize the behaviour of the graph of the Exchange Rate (y) in the Philippines along with its economic indicators such as Inflation Rate, Balance of Payments, Interest Rate, Producer's Price Index, Export, Import, Money Supply and Consumer's Price Index from January 2007 to October 2018. This analysis additionally means which among the economic indicators have a significant relationship to Exchange Rate (y) and which among them are the significant predictors to formulate a Multiple Linear Regression model. Moreover, the researchers will use these exogenous factors to be able to create a Multi-Layer Feed Forward Neural Network model. Finally, this study mainly focuses on finding the bestfitted model on forecasting the Exchange Rate (y) in the Philippines between Multiple Linear Regression and Multi-Layer Feed Forward Neural Network from October 2018 to December 2023.

1.2.Conceptual Framework

In this study, the historical data of Exchange Rate in the Philippines and its factors from January 2007 to October 2018 are collected on the Bangko Sentral ng Pilipinas (BSP) and Philippines Statistics Authority (PSA). The researchers means to foretell the rate of the aggregated information through Multiple Linear Regression (MLR) and Feed Forward Neural Network (FFNN). In addition, the researchers utilized five forecasting accuracy such as Root Mean Sum Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Mean Sum Error (MSE) and Normalized Mean Square Error (NMSE). These errors will discern the precision of Multi-layered Feed Forward Neural Network and Multiple Linear Regression. Also by this the researchers will conclude which is the best fitted model on predicting the data of exchange rate in the Philippines. In conclusion, we would now be able to acquire the predicted value of exchange rate in the Philippines from October 2018 and December 2023.

1.3.Statement of the Problem

This study aims to forecast the Monthly Exchange Rate (y) of the Philippines for the incoming 5 years (2018 to 2023) through MLR and to discern the significant factors by the software MATLAB. Hence the goal of this study is to answer the succeeding queries:

1.3.1 What is the behaviour of the graphs of independent variables and the Exchange Rate (y) of the Philippines from 2007 to 2018?

1.3.2 Is there any significant relationship between independent variables and the Exchange Rate (y) of the Philippines?

1.3.3 Which of the independent variables is a significant predictor of Exchange Rate (y) of the Philippines using Multiple Linear Regression?

1.3.4 What will be the Artificial Neural Network model of the Exchange Rate (y) of the Philippines?

1.3.5 What will be the monthly forecasted values of Exchange Rate (y) in the Philippines from October 2018 to December 2023?

1.4.Scope and Limitation of the Study

The researchers gathered data from January 2007 to September 2018 from Philippines Statistics Authority (PSA) of chosen eight factors influencing Exchange Rate (y) in particular; Inflation Rate (x_1), Balance of Payments (x_2), Interest Rate (x_3), Producer Price Index (x_4), Export (x_5), Import (x_6), Money Supply (x_7), and Consumer's Price Index (x_8). Through the assistance of theseables, the researchers utilized Multiple Linear Regression model and Multi-Layer Feed Forward Neural Network model to obtain the forecasted values of Exchange Rate (y) from the year October 2018 to December 2023.

1.5.Significane of the Study

Exchange Rate influence the economic growth since it serves as the relative value between two currencies. It also involves various goods, services and financial assets of local and overseas market.

From year 2007-2018, researchers noticed a gradual depreciation of Exchange Rate in the Philippines which implies that the value of peso diminishes slowly and it can affect the country's external sector through its impact on foreign trade.

Forecasting it for five years (2018-2023) will be valuable to the government to predict the future movements

of Exchange Rate using the best fitted model among Multiple Linear Regression and Multi-Layer Feed Forward Neural Network

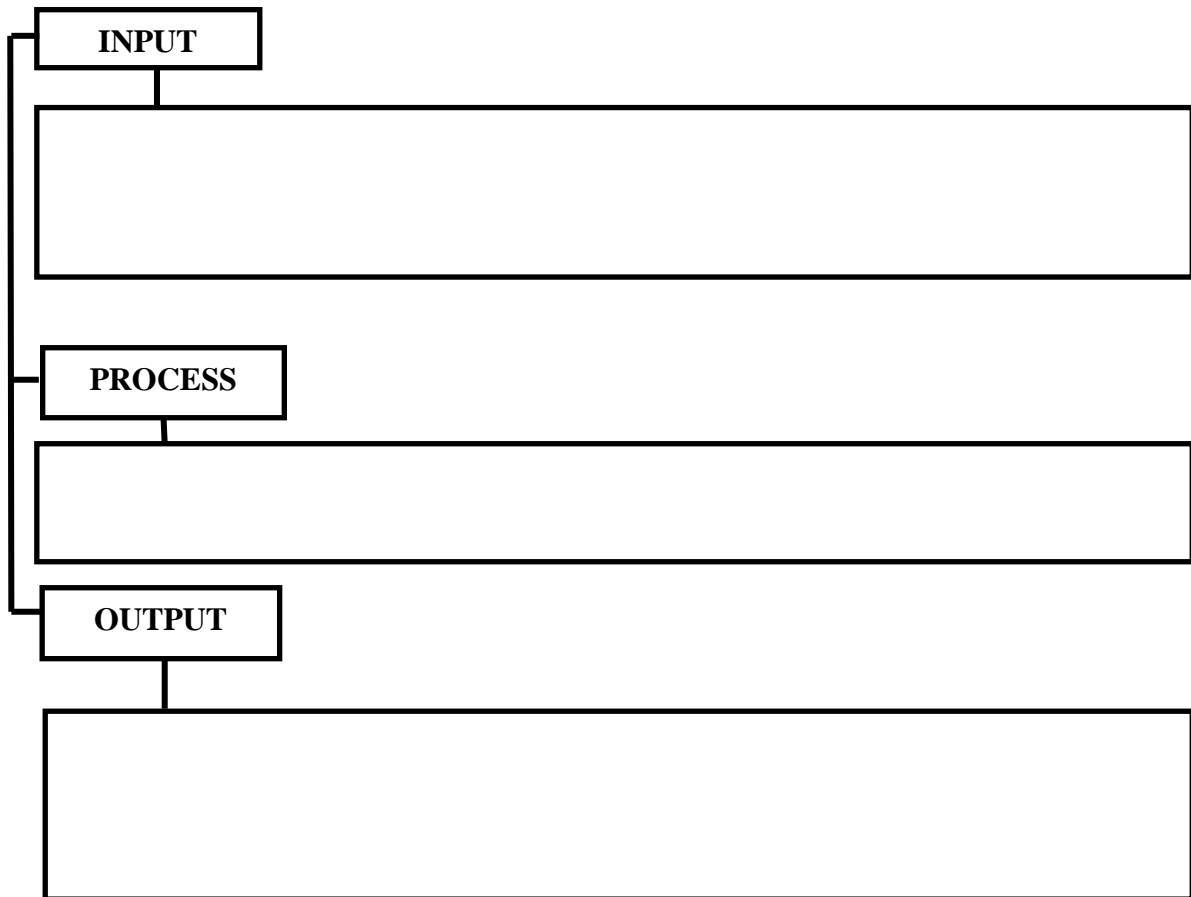


Figure 1.2.1. A Conceptual Framework for the study of Forecasting Exchange Rate in the Philippines.

2. Review of Related Literature

There are different kinds of artificial neural networks that can be used on forecasting a data. The following are the studies who used a multi-layered feed forward neural network on predicting the exchange rate of a certain country.

On the paper of Neural Network Based Forecasting

Foreign Exchange Rates (2014) the researcher reports the empirical proof that a neural network model is applicable to the prediction of foreign exchange rates.

It is confirmed that a neural network model is relevant to the prediction of foreign exchange rate. Trained neural network is used to forecast the exchange rate between Indian Rupee and four other distinct principals, Pound Sterling, US Dollar, Euro and Japanese Yen. Through three distinct learning algorithms, the Artificial neural network was trained with the gathered past data to determine the best algorithm for forecasting. One of those algorithms is Multilayer perception or Feed forward Neural Network. [7]

Based on the paper, "Currency Risk Management: Predicting the EUR/USD Exchange Rate" (2018), researchers used the multiple linear model and fitting of errors in momentum indicators to predict the fluctuation of exchange rate between US dollar and Euro. The Predictions developed were compared to the forward rates to generate a hedging strategy for choosing between forward contract or the spot exchange rate. Lastly, they were able to analyse the payoffs obtained by using this strategy. [8]

On 'Forecast Foreign Exchange with Both Linear and Non-Linear Models coupled with Trading Rules for Selected Currency' (2015), the researchers predicted the macro-cycles of three selected currencies namely, USD/JPY, CAD/JPY, and USD/CAD by using the macroeconomic fundamental variables as inputs. This was done by establishing a combination of parametric Markov model and nonparametric multi-layered feed forward neural network together with trading techniques. The results obtained validate that the combination models have

a significant predictive and market timing ability and outperform the benchmark models in terms of returns, however, their advantage diminishes in the periods of central bank intervention. [9]

In the paper entitled “Artificial Neural Network and Time Series Modelling Based Approach to Forecasting the Exchange Rate in a Multivariate Framework” (2016), the researchers chosen different explanatory variables from existing account and the capital account of the balance of payments For forecasting exchange rate, there are two distinct types of frameworks used: Artificial Neural Network (ANN) based models and Time Series Econometric models. Multilayer Feed Forward Neural Network and Nonlinear Autoregressive models with Exogenous Input are used as ANN models. Within the frameworks, it is concluded that ANN models are more efficient than using Time series Econometric Modelling. Specifically, Multilayer Feed Forward Neural Network and Nonlinear Autoregressive models are more reliable for forecasting. [10]

On the paper, “Performance Analysis of MLPFF Neural Network Back Propagation Training Algorithms for Time Series Data”, investigates the various training algorithm with Multi-Layer Perceptron Feed Forward Neural Network (MLPFFNN) and identify the best training algorithm for Indian Stock Exchange Market especially for BSE100 and NIFTY MIDCAP50. The forecasting accuracy is analysed and measured with reference to an Indian stock market index such as Bombay Stock Exchange (BSE) and NIFTY MIDCAP50 in this study and it is found that the best training algorithm is Levenberg-Marquardt. All Training algorithms uses the 1-5-1 MLPFFNN architecture and its various parameter such as epochs, learning rate, etc are studied and the results are tabulated for the data division ratio 60%, 20% and 20% which represents training, validating and testing for all training algorithm. [11]

It is concluded that the best Multilayer Perception neural network topology has been formulated and examined through particular generic algorithm multi-objective objective Pareto-Based to efficiently forecast the Exchange of Euro per Us dollar with the given factors or variables. The ANN model which have developed can greatly predict the movement to three days of exchange rate of Euro and Us dollar. [12]

In this paper, the feed forward neural network is can be examined through Levenberg Marquardt Learning Algorithm for efficient forecasting. There are different indicators for its performance to meet the optimal network topology. Also, it is determined that this kind of network has three layers which are input, hidden and output layer. It is concluded that this artificial neural network is the appropriate method for Foreign currency exchange prediction. In addition, Mathlab software is the tool used for running artificial neural network. [13]

In this study, both Artificial Neural Network and Autoregressive Integrated Moving Average time series are used for Malaysian foreign trading rate. Choosing Feed forward neural network as neural network's method because this method has been proven to be consistent method for forecasting. This network exhibits a smaller mean square error and root mean square error as compared to Autoregressive Integrated Moving Average time series. Basically, it is concluded that ANN method using the feed forward neural network is fitted to be the forecasting method in this paper. [14]

In the paper, " Financial Time Series Forecasting Using Empirical Mode Decomposition and FNN", a study on Selected Foreign Exchange Rates the researchers have proposed many hybrid computing device getting to know models to get a more accurate forecast. A hybrid forecasting model using Empirical Mode Decomposition and Feedforward Neural Network for foreign trade charges forecasting and evaluating its overall performance with broadly used Non-linear Autoregressive and Support Vector Regression models. EMD is used to decompose the unique non-linear and non-stationary series into various Intrinsic Mode Functions (IMFs) and one residual. The hybrid model is then used to forecast the alternate charge with IMFs and residual obtained as inputs. Empirical results obtained from forecasting day by day exchange charges of Sri Lankan Rupees to Euro and Yen confirmed that the proposed EMD-FNN models outperforms NAR and SVR models without time sequence decomposition. [15]

In this paper," A Comparison of Different Model Selection Criteria for Forecasting EURO/USD Exchange Rates by means of Feed Forward Neural Network" , a lot of FFNN models are examined to forecast EURO/USD trade charge time series and distinct model decision criteria are used to determine the high-quality architecture for the data. For this purpose, EURO/USD time sequence determined weekly from January of 1999 to January of 2016 is forecasted by means of using FFNN. To pick out exclusive architectures according to distinctive performance criteria, a computer application was once coded with the aid of the use of MATLAB. As a result of the implementation, all acquired consequences are presented and interpreted. [16]

In the paper "Statistical Analysis of Foreign Exchange Rate and FDI (2017)", this article focusses to study whether or not GBP to CNY alternate fee has some relationship with FDI flowing to UK and China in share to their GDP size. After performing more than one regression evaluation on the sample data, we have determined statistical dimension to reject the null hypothesis (partially). This concluded that statistically there is some relationship between GBP/CNY exchange fee with FDI flowing to China. [17]

On the paper of Chander S. et al., entitled, "Foreign Exchange Rate using Levenberg-Marquardt Learning Algorithm" (2016), the researchers investigate the exchange rates between Indian Rupee and four major currencies namely, Euro, Japanese Yen, Pound Sterling, and US Dollar. Researchers used neural networks trained with Levenberg Marquardt Learning algorithm with the use of MATLAB tool. Simulation results show that the proposed technique is an effective tool for FOREX prediction with proper construction of network model.[18]

The paper "On the determinants of the THB/USD exchange rate (2015)", used the Multiple Linear Regression, it shows that phrases of trade and international reserves have an enormous impact on the THB/USD trade rate over the duration in the study. Terms of exchange have a bad relationship with the THB/USD alternate rate at a 95% self-assurance level. By contrast, global reserves have a good relationship with the THB/USD change rate. The coefficient of terms of exchange is the highest, which has the potential that terms of exchange have the strongest relationship with the THB/USD change rate, and is observed by using global reserves. The elements affecting the alternate price between two currencies can't be completely defined by linear regression evaluation alone. Therefore, it would be fascinating to include a quantity of alternative methods, such as sentimental evaluation or dynamic regression to get a greater accurate result. [19]

The outcome of the paper "Effect of Exchange Rate Volatility on Nigeria Economy 1991-2010 (2013)" focuses on the effect of trade rate volatility on economic increase in Nigeria. In conclusion, having validated the importance of the relationship between the GDP, export and trade and different variables authorities reactivate non-oil sectors of the financial to manage the exchange price volatility. [20]

3. Methodology

3.1. Statistical Methods

Statistical methods are mathematical formulas, models, and techniques that are utilized in the measurable examination of crude research information. The requisition of statistical methods extracts information from research data and provides distinct approaches to evaluate the strength of research yields. In this study, the researcher employed the following statistical methods:

3.1.1 Multiple Linear Regression

Multiple linear regression (MLR) is a statistical technique that is used to foresee a result of a response variable (dependent variable) using informational factors also known as the independent variables. The purpose of MLR is to build a linear model which would represent the relationship between the dependent and independent (predictor) variables.

The formula for multiple linear regression is

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \beta_p x_{ip} + e$$

where for $i = n$ observations, y_i is the dependent variable, x_i is the predictor variables, β_0 is the y-intercept, β_p is the coefficient of the slope of each explanatory variables, e represents the model's error term. [22]

H₀: There is no relationship between independent variables (x) and dependent variable (exchange rate).

H_a: There is a relationship between independent variables (x) and dependent variable (exchange rate).

Level of significance is 0.05

The following are the qualifying assumptions for multiple regression model:

Linearity

Standard multiple regression can just precisely gauge the connection between dependent and independent variables if the relationships are linear in nature. [23] In this study, the researcher will test the linearity utilizing Pearson's r correlation coefficient.

Pearson's r correlation is used for measuring association or the statistical relationship between two continuous variables. It is based on the method of covariance, hence considered as the best technique for measuring association between factors of intrigue. It also gives information regarding the magnitude of the association, or correlation, and also the direction of the relationship. Statistics that measure the statistical relationship, or association between two continuous variables. [24]

The statistical hypotheses of the Pearson's r are:

H₀: There is no significant relationship.

H_a: There is a significant relationship.

The formula for Pearson's r is:

$$r = \frac{N \sum xy - (\sum x)(\sum y)}{\sqrt{[N \sum x^2 - (\sum x)^2][N \sum y^2 - (\sum y)^2]}}$$

where N represents the number of pair scores, x is the single value/score from the pair scores, and y as the other value/score from the pair scores. The value of the coefficient is between -1.00 and 1.00. A negative coefficient value indicates that there is a negative correlation between the relationship of the variables, that is, as the other value increases, the other one decreases. On the other hand, a positive coefficient value means that there is a positive correlation on the relationship between the variables. Hence, both values decrease or increase together. [25]

Normality

Normality is one of the most significant assumption for regression analysis: There are different tests that we can use to check if a given data is normal. Hence, in this study we will use Jarque-Bera test.

The Jarque-Bera test is based on the sample skewness and sample kurtosis.

Ho: The residuals of the data follow a normal distribution.

Ha: The residuals of the data do not follow a normal distribution.

The formula is given as:

$$JB = \frac{n}{6} \left(s^2 + \frac{(k - 3)^2}{4} \right)$$

where n is the sample size, s is the sample skewness and k is the sample kurtosis. A large J-B value indicates that errors are not normally distributed. [26]

Multicollinearity

One of the assumptions of multiple linear regression is that the predictor variables are not highly correlated with one another.[27] There is a presence of Multicollinearity when there exists a correlation, or a linear relationship between two independent variables. In layman's term, a existence of multicollinearity between independent variables means a unreliable prediction of a regression analysis. In this paper, Variance Inflation Factor will be used on validating the multicollinearity's assumption.

The variance inflation factor (VIF) detects multicollinearity within the regression model. VIF ranges from 1 upwards (in decimal form). A value equal to 1 means that there is no correlation, value between 1 to 5 means moderately correlated ,and lastly, values greater than 5 shows a high correlation. [28]

The statistical test hypotheses are:

Ho: $\beta_1 = 0$

Ha: $\beta_1 \neq 0$

The formula is given as:

$$VIF = \frac{1}{1 - R_k^2}$$

where R_k^2 is the R²-value obtained by regressing the kth predictor on the remaining predictors. Note that a variance inflation factor exists for each of the k predictors in a multiple regression model. [29]

Homoscedasticity

This assumption means that there is an existence of similarity between the variance of error terms across the values of the predictor variables. Plotting of predicted values vs standardized residuals can show whether points are equally distributed across all values of the predictor variables. In this analysis, Breusch- Pagan test was used to verify the homoscedasticity.

Breusch-Pagan test (named after Adrian Pagan and This test measures how errors varies across the dependent variable. It also assumes that linear functions of one or more explanatory variables in the model affects the error variances.

This means that there could be a presence of heteroskedasticity in the regression model, however, those errors (if present) aren't correlated with the Y-values.

The test hypotheses are:

H_o : The residual squared of the data is homoscedastic.

H_a : The residual squared of the data is heteroscedastic.

The formula for Breusch-Pagan test is:

$$B_p = N * R^2 \text{ (with } k \text{ degrees of freedom)}$$

where R^2 = (Coefficient of Determination) of the regression of squared residuals from the original regression, n represents the sample size, and k represents number of independent variables. [30]

Independence

Durbin Watson (DW) statistic is a test for serial correlation (autocorrelation) in the residuals from a regression analysis. The values from a Durbin Watson statistic ranges between 0 and 4. A value of 2 indicates that there is no presence of autocorrelation. Values less than 2 means that there is a positive autocorrelation while values greater than 2 indicates negative autocorrelation. [31]

The hypotheses for Durbin-Watson test are:

H_o : $\rho = 0$

H_a : $\rho > 0$

The test statistic is calculated using the formula:

$$d = \frac{\sum_{i=2}^n (e_i - e_{i-1})^2}{\sum_{i=1}^n e_i^2}$$

where $e_i = y_i - \hat{y}_i$ and y_i and \hat{y}_i are, respectively, the observed and predicted values of the response variable for individual i . d becomes smaller as the serial correlations increase. [32]

3.1.2. Multi-Layer Feed Forward Neural Network

Multi-layer Feedforward neural network or multilayer perceptron is a neural network model consisting of two layers namely, the input layers and the hidden layers, and an output. It is a model that shows the interconnection of perceptron's wherein the calculations and data flows from the input data to outputs. The number of layers of perceptron's is the number of layers in a neural network..

The figure below represents flow of using Multi-Layer Feed Forward Neural Network:

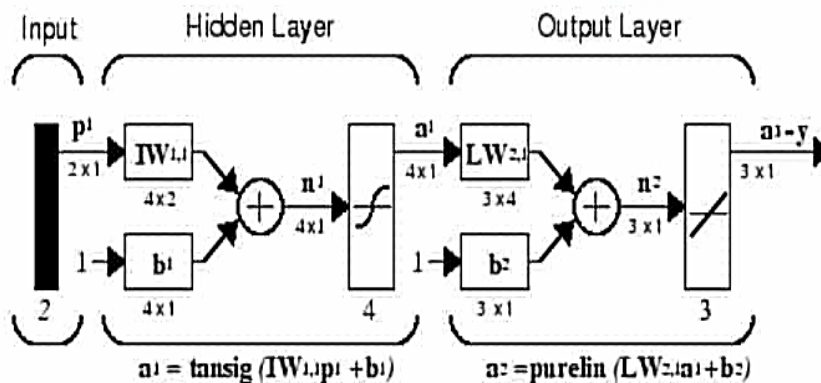


Figure 3.2.1. Multi-Layer Feed Forward Neural Network

The figure 3.2.1 shows multiple layers. Thus architectures of this class besides possessing an input and an output layer also have one or more intermediary layers called hidden layers. The hidden layer aids in performing useful intermediary computations before directing the input to the output layer. The input layer neurons are linked to the hidden layer neurons and the weights on these links are referred to as input hidden layer weights. Again the hidden layer neurons are linked to the output layer neurons and the corresponding weights are referred to as hidden-output layer weights. [33]

3.1.3. Measurements Accuracy

In this study, the researchers used 5 distinct forecasting accuracy such as root mean sum error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), mean sum error (MSE) and Normalized Mean Square Error (NMSE). Also through these the researchers can decide which among the Multi-layered Feed Forward Neural Network and Multiple Linear Regression model is best fitted on Forecasting the Exchange Rate in the Philippines.

3.1.4. Mean Sum Error (MSE)

Mean squared error is a value that is used for goodness of fit of the regression line. A smaller Mean Sum Error means a better fit. It also implies a smaller degree of error. For example, consider the hypothetical example where all data points lie exactly on the regression line. This would yield residual errors of 0 for all points, and the MSE calculation would also be 0, which is the smallest possible MSE value.

We can take a closer look at the MSE calculation by forcing our sample data into two subsets that have different characteristics. If we divide the data based on their individual residual error terms and calculate the MSE for each subset separately, the data samples with the smallest errors should have a much smaller mean squared error than the subset of data with the largest errors.

$$MSE = \frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2.$$

where n is the number of data points, Y_i represents the observed values, and \hat{Y}_i represents the observed values. [34]

3.1.5. Root Mean Square Error (RMSE)

Mean Square Error (RMSE) is the standard deviation of the residuals or prediction errors. Residuals measures the distance of line data points from the regression line; RMSE measures the dispersion of these residuals. Thus, it tells the robustness of the data from the line of best fit. RMSE is widely used in forecasting, climatology, and in regression analysis for verifying experimental results. [35]

The formula for RMSE is: [36]

$$RMSE = \sqrt{\frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2}$$

3.1.6. Normalized Mean Square Error (NMSE)

Normalized Mean Square Error (NMSE) estimates the deviations between measured and predicted variables by getting the total of deviations. A low NMSE indicates that the model performs well in both space and time. However, a higher NMSE values doesn't imply that the model is inaccurate. This case could be an effect of time or/and space shifting.

. [37]

$$NMSE = \frac{1}{n} \sum_{i=1}^n \frac{(Y_i - \hat{Y}_i)^2}{\bar{Y}_i \bar{\hat{Y}}_i}$$

where

$$\bar{Y}_i = \frac{1}{n} \sum_i Y_i$$

and

$$\bar{\hat{Y}}_i = \frac{1}{n} \sum_i \hat{Y}_i$$

3.1.7. Mean Absolute Error (MAE)

The Mean Absolute Error (MAE) is the average of all absolute errors, measured in same units as the data. The amount of error in the measurements is called absolute errors. It is the difference between the true value and

measured value. This is easier statistic to understand than the RMSE. MAPE and MAE which are usually used in the output of time series forecasting methods. [38]

$$MSE = \frac{1}{n} \sum_{i=1}^n (Y_i - \hat{Y}_i)^2.$$

3.1.8. Mean Absolute Percentage Error (MAPE)

Mean Absolute percentage error (MAPE), also known as Mean Absolute Percentage Deviation (MAPD), measures the accuracy of a predicting method in statistics. The size of the error is measured in percentage terms for simple understanding. This method is commonly used for it is easy to explain and applies easily to both high and low volume of data. [39]

$$MAPE = \frac{100\%}{n} \sum_{i=1}^n \left| \frac{Y_i - \hat{Y}_i}{Y_i} \right|$$

4. Results and Discussions

4.1. Behaviour of Graphs of the Variables

In this section, the researchers established the graphs of Exchange rate (y) in the Philippines and its Independent variables such as Inflation rate(x₁), Balance of Payments(x₂), Interest Rate(x₃), Producer’s Price Index (x₄), Export(x₅), Import(x₆), Money Supply(x₇), and Consumer’s Price Index(x₈) from January 2007 to October 2018.

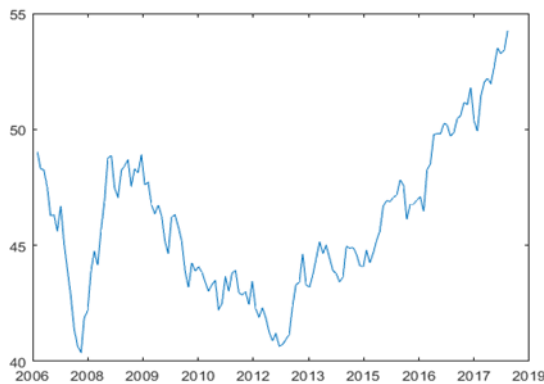


Figure 4.1.1. Graph of the Exchange rate of the Philippines from January 2007 to October 2018

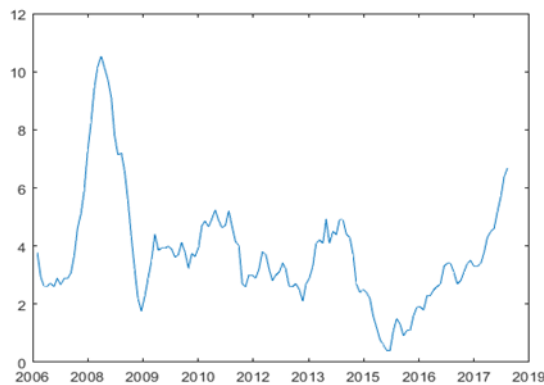


Figure 4.1.2: Graph of Inflation rate of the Philippines from January 2007 to October 2018

Exchange Rate (y)

In the extent of 10 years, the Peso-Dollar Exchange Rate (See Figure 4.1.1) on the end of 2007 hits 41.28 peso per US dollar. It appreciated by 18.8% versus the US dollar and on this year the Philippine peso was regarded as the best performing currency in Asia due to the amount of remittances from an estimated eight million OFW

(Overseas Filipino Workers). [40] As you can discern on the graph the Philippine peso depreciates in 2018, and according to Rappler it is the weakest currency in ASEAN due to the “build build build” program of the government that resulted to a widening trade deficit. [41]

Inflation Rate (x₁) The Philippines Inflation Rate (See Figure 4.1.2) in 2008 reached 9.3 per cent, it was said that the increase is due to the oil price hike and food commodities. [42] However, in 2015 it declines due to the slower increase on the price of the goods and services. According to the Bangko Sentral ng Pilipinas (BSP) annual report the food inflation rate was lower on this year by 2.6 per cent for 7.1 on the previous year. [43]

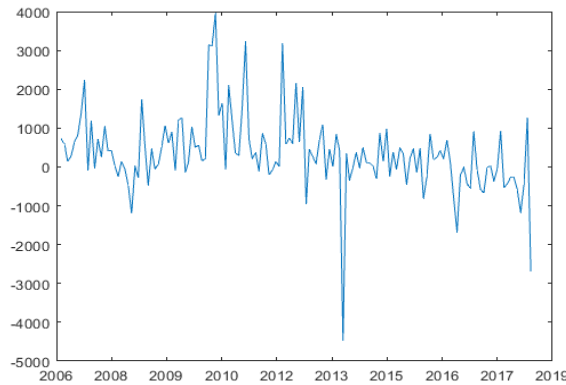


Figure 4.1.3: Graph of Balance of Payments of the Philippines from January 2007 to October 2018

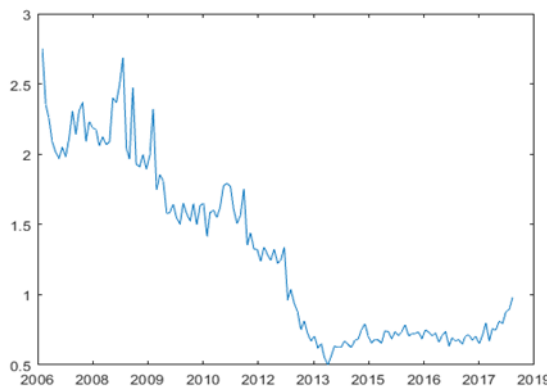


Figure 4.1.4: Graph of Interest Rates of the Philippines from January 2007 to October 2018

4.1.1. Balance of Payments (x₂)

The Philippines Balance of Payments (BOP) (See Figure 4.1.3) in 2009 attained a surplus of 5.3 billion US dollars according to the Bangko Sentral ng Pilipinas (BSP). It is due to the decline of imports and commodity prices. It was shown that on the span of 11 years the BOP was on its peak on the said year. [44] However, in 2013 the balance of payments achieved a surplus of 5.1 billion US dollars. “Strong Overseas Filipino remittances as well as robust business process outsourcing, and tourism receipts helped to support the external payments position” stated by the Bangko Sentral ng Pilipinas. [45]

4.1.2. Interest Rate (x₃)

The Domestic interest rate (See Figure 4.1.4) in 2007 was relieved due to the “ample liquidity in the financial system” according to the Bangko Sentral ng Pilipinas.[46] Also, on this year the Interest rate of the Philippines was on its tip. On the other hand, in 2013 the domestic interest rate declined and considered as the lowest interest rate on the span of 11 years (from 2007 to 2018). A low interest rate will result to an increase on the spending of the host and a decrease on investment from the foreign countries; this will result to the declining of a host country’s economy. [45]



Figure 4.1.5. Graph of Producer’s Price Index of the Philippines from January 2007 to October 2018

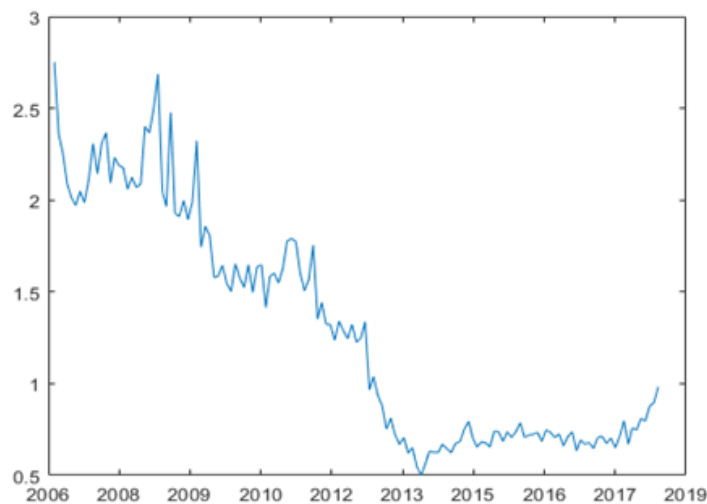


Figure 4.1.6. Graph of Export of the Philippines from January 2007 to October 2018

Producers Price Index (x_4)

The Producers Price Index (PPI) is defined as the statistical measure of the average changes in average prices of a basket of goods as they leave the

establishment of the producers relative to a base period. In 2008 (See Figure 4.1.5) the producer price index for manufacturing industries went up by 3.5 per cent according to the Bangko Sentral ng Pilipinas. This is due to the increase by fourteen major sector such as petroleum products which increased by 42.1 per cent, basic metals which gained an increase of 20.6 per cent, and textiles which achieve an increase of 12.2 per cent.[47] In 2018 the producer price index marks its lowest on the span of 11 years due to the negative growths of nine major sectors such as Food Manufacturing, Fabricated Metal Products, Chemical Products, Rubber and plastic products, Furniture & Fixtures, Transport Equipment, Footwear & Wearing Apparel, Wood & Wood Products, and Leather Products. On the other hand, maintained an upward trend compared to the previous year. [48]

4.1.3.Export (x_5)

The Export (See Figure 4.1.6) in May 2009 dropped by 24.3% since the total external trade in good for the month of January to May 2009 declined by 33.7 %. Exports of goods for the full year 2009 contracted by 22.3 percent as all major export commodity groups posted declines, except for sugar and products. [49] However, the import for the month of July on 2018 grew by 31.6 % according to the annual report of the Central Bank of The Philippines, “The increase was due to the positive growth of the 9 out of the top 10 major import commodities for July 2018” such as iron and steel, transport equipment, electronic product and more. [50]

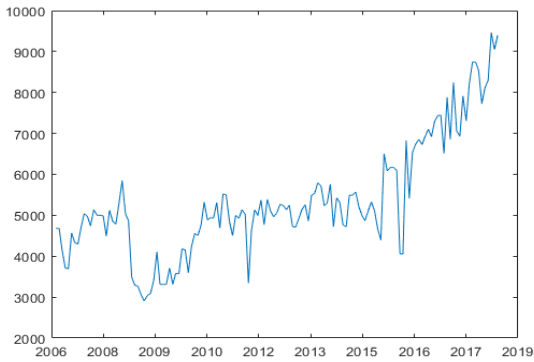


Figure 4.1.7. Graph of Import of the Philippines from January 2007 to October 2018

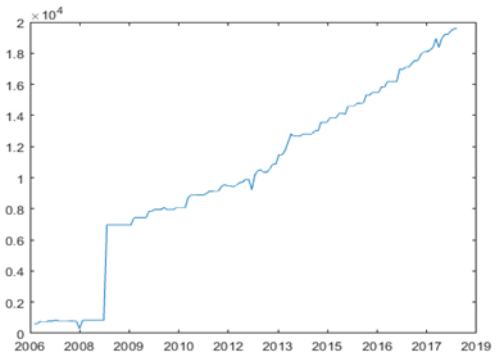


Figure 4.1.8. Graph of Money Supply of the Philippines from January 2007 to October 2018

4.1.4.Import (x6)

The Import (See Figure 4.1.7) marks its lowest in 2009, low import will result to an appreciation of exchange rate. The decline on import is due to the contraction in all major commodity groups given weak global prices of most commodities, particularly mineral fuels and lubricants, and raw material inputs for electronics exports. [44] Hence, in 2018 the Philippine import increased by 100.7 billion US dollars according to Bangko Sentral ng Pilipinas, the increase was due to the high imports across all major commodity groups, notably raw materials and intermediate goods, indicating increased domestic production activity. [51]

4.1.5.Money Supply (x7)

The Money Supply (See Figure 4.1.8) in 2008 reached 11.1 trillion pesos in June as it grew by 11 per cent it is due to the amid a tempered increase in bank lending according to the Bangko Sentral ng Pilipinas.[52] Also, it grew by 12.4 per cent in December 2016, slower than the 12.7 per cent growth in November, according to the Bangko Sentral ng Pilipinas (BSP). Domestic liquidity amounted to P9.47 trillion in end December 2016, P1.04 trillion higher than the P8.43 trillion recorded in December 2015, latest data from the central bank showed. [53] Therefore, on the span of 11 years the money supply decline in 2008 and reached its peak in 2018.

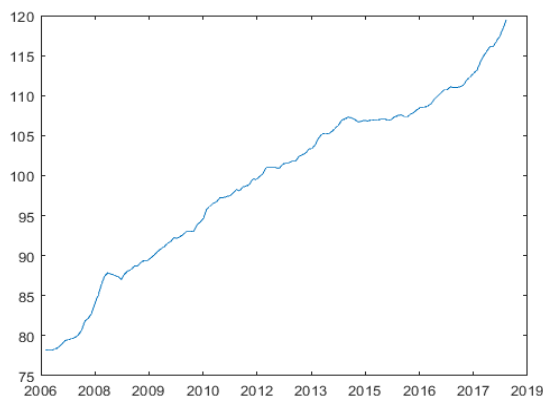


Figure 4.1.9. Graph of the Consumer Price Index of the Philippines From January 2007 to December 2018

4.1.6.Consumer Price Index (x8)

In December 2008, the Consumer Price Index (See the Figure 4.1.9) decreases by .4 per cent from November 2008 because the prices of LPG, kerosene, gasoline, and diesel reduces. Also, the rates and price reductions of electricity and foods contributed to decrease the index. And, CPI in June 2017 dropped by 111.0 because the items such as rice, corn fish, vegetables and meat had an upward price adjustment. In addition, the tuition fee hikes in most of the province in the Philippines, according to PSA. [40]

4.1.7. Significant Relationship Between Independent Variables and the Exchange Rate (y) of the Philippines

The figures below represent the scatterplot of the independent variables and Exchange Rate (y):

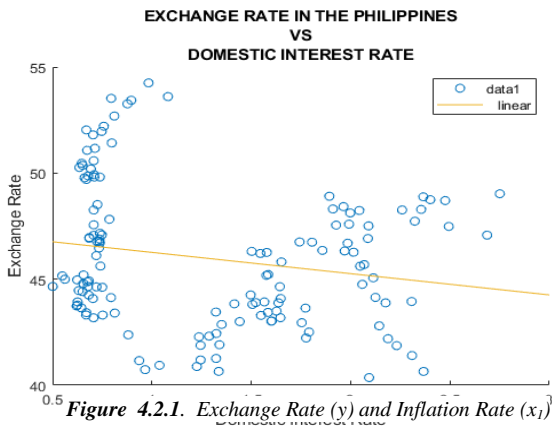
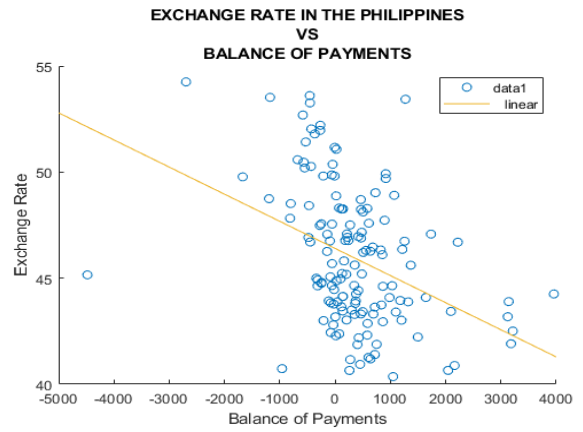
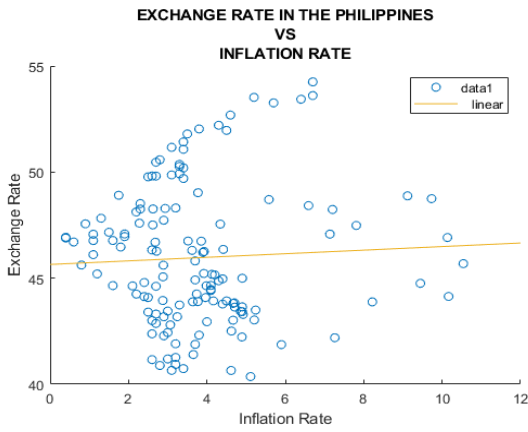


Figure 4.2.1. Exchange Rate (y) and Inflation Rate (x_1)

Figure 4.2.2. Exchange Rate (y) and Balance of Payments(x_2)

Figure 4.2.3. Exchange rate(y) and Domestic Interest rate (x_3)

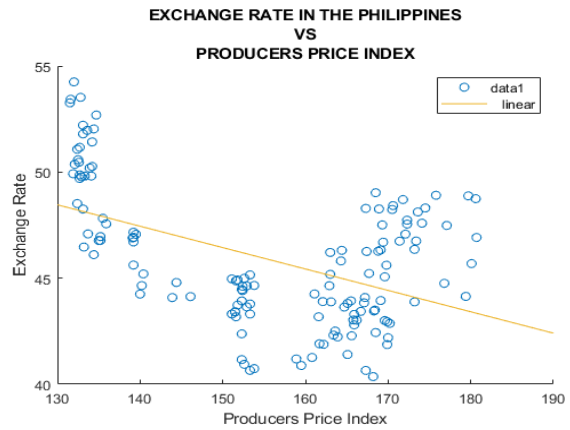


Figure 4.2.4. Exchange rate (y) and Producers Price Index (x_4)

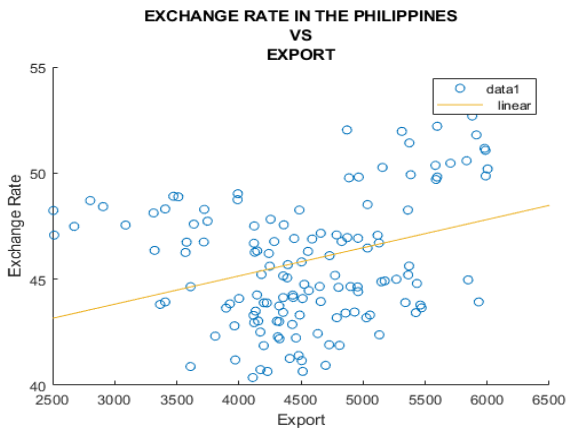


Figure 4.2.5. Exchange Rate (y) and Export (x_5)

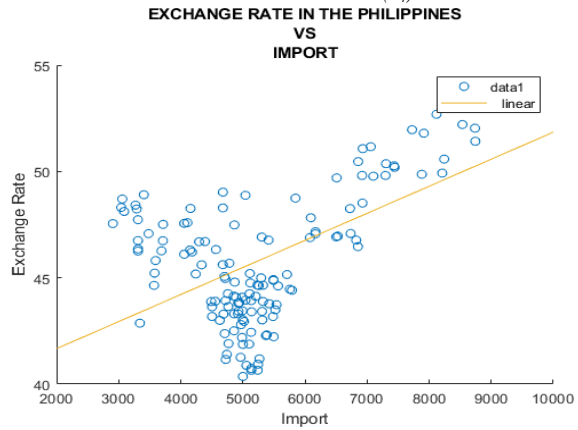


Figure 4.2.6. Exchange Rate (y) and Import (x_6)

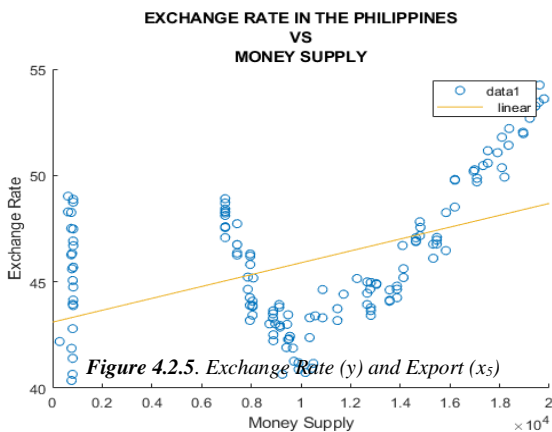


Figure 4.2.7. Exchange rate (y) and Money Supply (x_7)

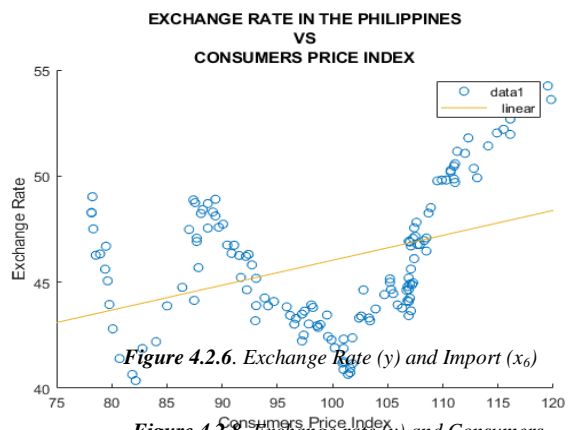


Figure 4.2.8. Exchange rate (y) and Consumers Price Index (x_8)

Notice

that the figure 4.2.1 which is Inflation Rate(x_1) forms a straight line. this means there is no significant relationship between inflation rate and exchange rate. Also, in figure 4.2.2, 4.2.3, and 4.2.4 which are Balance of Payments(x_2), Interest Rate(x_3) and Producer Price Index(x_4) respectively form a decreasing line. This means that the correlation between Balance of Payments(x_2), Interest Rate(x_3) and Producer Price Index(x_4) in Exchange rate(y) are moderately strong. Thus, we can say that there is significant relationship between Balance of Payments(x_2), Interest Rate(x_3) and Producer Price Index(x_4) in Exchange rate(y). Lastly, figure 4.2.5, 4.2.6, 4.2.7 and 4.2.8 form a line with a positive slope and increasing. This means Export(x_5), Import(x_6), Money Supply(x_7), and Consumer's Price Index(x_8) in Exchange Rate(y) also have a significant relationship.

The table below shows the relationship of independent variable to the Exchange Rate (y)

Independent Variable	Pearson's r	Verbal Interpretation	p-value	Decision	Remark
Inflation Rate	0.250	Weak correlation	0.766	Failed to Reject Ho	Not significant
Balance of Payments	-0.384	Weak correlation	0.000	Reject Ho	Significant
Interest Rate	-0.190	Veryweak correlation	0.024	Reject Ho	Significant
Producer Price Index	-0.486	Moderately strong correlation	0.000	Reject Ho	Significant
Export	0.327	Weak correlation	0.000	Reject Ho	Significant
Import	0.550	Moderately strong correlation	0.000	Reject Ho	Significant
Money Supply	0.466	Moderately strong correlation	0.000	Reject Ho	Significant

Table 4.2.1. Relationship of Independent Variables to the Exchange Rate (y) of the Philippines

Legend: $|r| = 0.00$: no correlation, $0.0 < |r| < 0.2$: very weak correlation, $0.2 \leq |r| \leq 0.4$: weak correlation, $0.4 \leq |r| \leq 0.6$: moderately strong correlation, $0.6 \leq |r| \leq 0.8$:strong correlation, $0.8 \leq |r| < 1.0$: very strong correlation, $|r|=1.0$: perfect correlation, $-1 = |r|$ negative correlation. Pvalue 0.05. Reject Ho if $p < 0.05$ and failed to reject if $p \geq 0.05$.

In table 4.2.1, it is shown that Balance of Payments (x_2), Interest Rate (x_3), Producer Price Index (x_4), Export (x_5), Import (x_6), Money Supply (x_7), and Consumer's Price Index (x_8) have a significant relationship to Exchange Rate (y) in the Philippines for having a p-value less than $\alpha=0.05$. In contrast, the Inflation Rate (x_1) is not significantly related to Exchange Rate (y) for having a p-value of 0.766 which is greater than $\alpha=0.05$.

4.1.9. Significant Predictor of Exchange Rate (y) of the Philippines

The table below shows the significant predictors of Exchange Rate (y):

Table 4.3.1. Regression Analysis

Variables	Beta Parameter	p-value	Decision	Remarks
Balance of Payments (x_2)	-0.0007	0.0038	Reject Ho	Significant
Import (x_6)	0.0013	0.000	Reject Ho	Significant

Upon running the multiple regression assumptions, pearson r shows that Inflation Rate (x_1) has no significant relationship with the dependent variable, Exchange Rate(y). For the test for multicollinearity, Interest Rate (x_3), Producer's Price Index (x_4) and Money Supply (x_6) have a variance inflation factor greater than 10 which shows that these independent variables are highly correlated with each other. Using durbin watson statistic, it was shown that residual has no autocorrelation by having a p-value equal to 1.972. For testing the normality of residuals, jarque bera test was used, the obtained p-value was 0.50 which implies that normality was satisfied. Finally, bruesch pagan test was used to check for homoscedasticity and the obtained p-value was 0.0729 which shows that homoscedasticity test was satisfied.

4.4.9 Multiple Linear Regression Model:

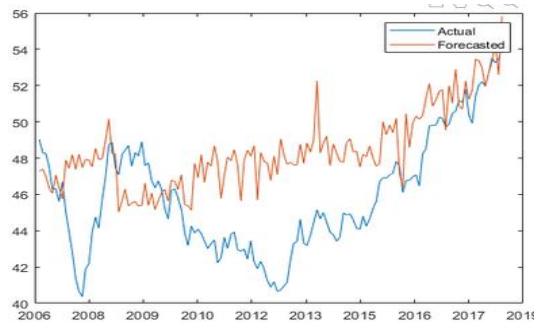
Upon satisfying the assumptions of Multiple Linear Regression, a new model is formulated since the only significant predictors are Balance of Payments (x_2), and Import (x_6). The model in forecasting Exchange Rate (y) accurately:

$$\hat{Y} = 41.7111 - 0.0007x_2 + 0.0013x_6$$

4.4.1 Actual vs Predicted Graph using Multiple Linear Regression

The graph below represents the actual and forecasted Exchange Rate (y) in th Philippines using Multiple Linear Regression:

Figure 4.3.2.1. Actual and Predicted graph of Exchange Rate (y)



In figure 4.3.2.1, it was shown that there is a fluctuation of the actual and predicted values of Exchange Rate (y) in the Philippines. However, the predicted values of Exchange Rate (y) is much more higher than the actual.

4.4.10. Multi- Layer Feed Forward Neural Network

4.4.1 Multi- Layer Feed Forward Neural Network Model

The figure below shows the Multi-Layer Feed Forward Neural Network model which is used for forecasting Exchange Rate (y) in the Philippines:

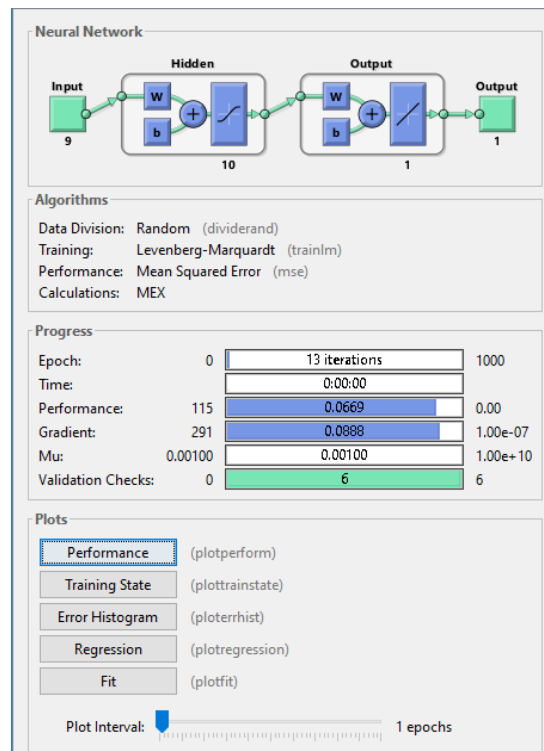


Figure 4.4.1.1. Training of Multi-Layer Feed Forward Neural Network

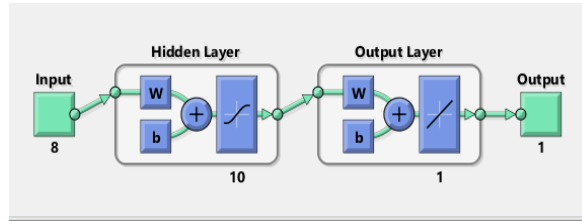


Figure 4.4.1.2. Multi-Layer Feed Forward Neural Network Model

Using the Neural Network Fitting App, the researchers considered the eight exogenous variables such as Inflation Rate (x_1), Balance of Payments (x_2), Interest Rate (x_3), Producer Price Index (x_4), Export (x_5), Import (x_6), Money Supply (x_7), and Consumer’s Price Index (x_8) as the Inputs while the Exchange Rate (y) as the target. Also, the researchers used the default percentage of 70% for training , 15% for both validation and testing. In addition, 10 hidden neurons was used in the hidden layer. Consequently, a Multi-Layer Feed Forward Neural Network model was created. Afterwards, this model was trained using the Levenberg-Marquardt training algorithm. The training will continue until the MSE or Mean Square Error reached a value that is close to 0 and the Regression value that is close to 1. After satisfying the training, the generated code was used for forecasting Exchange Rate (y) in the Philippines.

4.4.11. Actual vs Predicted Graph using Mult-Layer Feed Forward Neural Network

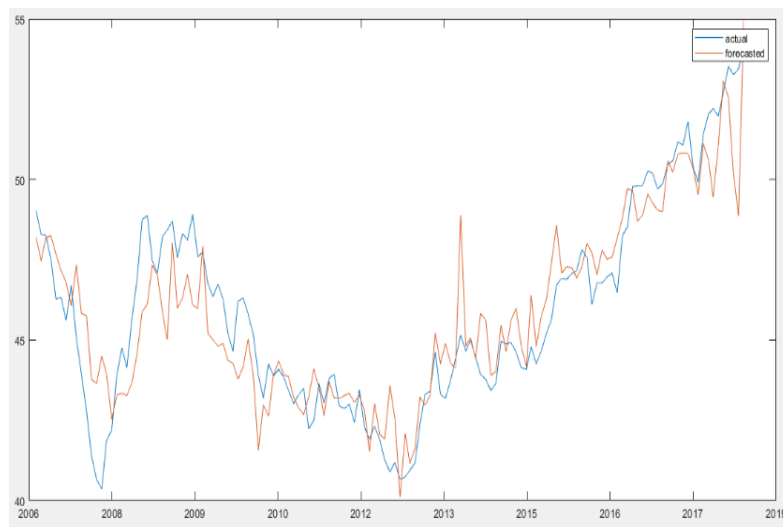


Figure 4.5.1.1. Actual and Forecasted Graph of Exchange Rate (y) in the Philippines

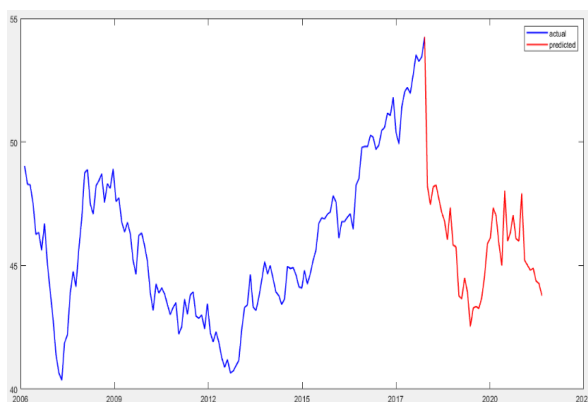
Figure 4.4.2.1. Actual vs Predicted of Exchange Rate (y) in the Philippines

It was shown above the similar fluctuations of actual and predicted value of Exchange Rate (y) in the Philippines using the Multi-Layer Feed Forward Neural Network from the year 2007-2018. The predicted values of Exchange Rate (y) are much more higher than of Actual values.

Forecasted Accuracy and Forecasted Values

Actual vs Forecasted Graph

The graph below represents the actual and forecasted values of the Exchange Rate (y) in the Philippines using Multi-Layer Feed Forward Neural Network:



The figure above shows the combined graph of Exchange Rate (y) from 2007-2018 and the forecasted Exchange Rate (y) from 2018-2023. The graph shows that the Exchange Rate (y) had the lowest value on the last months of 2007 and continues to increase on the year 2008. On 2009, the Exchange Rate value decreases continuously until the 5th and 6th months of 2012 then fluctuated again until September 2019. On the other hand, the forecasted values of Exchange Rate from October 2018 to December 2023 also have a fluctuation. However, there will be a huge down fall of Exchange Rate (y) from the month of September 2018 to October 2018.

4.1.12 Forecasting Accuracy

The table below shows the comparison of the errors of Multiple Linear Regression model and Multi-Layer Feed Forward Neural Network model.

Table 4.5.2.1. Comparisons of errors of two models on forecasting Exchange Rate (y) in the Philippines

Model	MAE	MSE	RMSE	MAPE	NMSE
MLR MODEL	1.4751	13.051	3.6126	0.0520	13.0506
ANN MODEL	0.8877	1.4138	1.890	0.0136	1.4138

The Multi-Layer Feed Forward Neural Network model has low errors compared to Multiple Linear Regression model (see Table 4.5.2.1) in all the five measurement accuracy. We can say that Multi-Layer Feedforward Neural Network is the best fitted model for forecasting the Exchange Rate (y) in the Philippines.

4.1.13. Forecasted Values using Multi-Layer Feed Forward Neural Network

The table below shows the forecasted values of Exchange Rate (y) in the Philippines using Multi-Layer Feed Forward Neural Network:

Table 4.5.3.1. Forecasted Values of Multi-Layer Feed Forward Neural Network

MONTH	FORECASTED VALUE
October 2018	48.2029
November 2018	47.4668
December 2018	48.1843
January 2019	48.2473
February 2019	47.6732
March 2019	47.1579
April 2019	46.8024
May 2019	46.0454
June 2019	47.3389
July 2019	45.8268

August 2019	45.7559
September 2019	43.7719
October 2019	43.6472
November 2019	44.4961
December 2019	43.9223
January 2020	42.5325
February 2020	43.2765
March 2020	43.3426
April 2020	43.2634
May 2020	43.6845
June 2020	44.5939
July 2020	45.8781
August 2020	46.1148
September 2020	47.3307
October 2020	47.0129
November 2020	45.8553
December 2020	45.0004
January 2021	48.0241
February 2021	45.9873
March 2021	46.3058
April 2021	47.0400
May 2021	46.0873
June 2021	45.9871
July 2021	47.9163
August 2021	45.2054
September 2021	45.0063
October 2021	44.8087
November 2021	44.8907
December 2021	44.3683
January 2022	44.2679
February 2022	43.7800
March 2022	44.1565
April 2022	45.0226
May 2022	43.9167
June 2022	41.5670
July 2022	42.9770
August 2022	42.6340
September 2022	43.9329
October 2022	44.3369
November 2022	43.9122
December 2022	43.8583
January 2023	43.2253
February	42.8795

2023	
March 2023	42.6738
April 2023	43.2312
May 2023	44.0896
June 2023	43.5193
July 2023	42.6379
August 2023	43.7149
September 2023	43.1867
October 2023	43.1716
November 2023	43.2673
December 2023	43.3403

5. Conclusion and Recommendation

This study was able to determine the behaviour of the graph of Inflation Rate (x_1), Balance of Payments (x_2), Interest Rate (x_3), Producer Price Index (x_4), Export (x_5), Import (x_6), Money Supply (x_7) Consumer's Price Index (x_8) and Exchange Rate (y) using Matlab software. Also, it is shown that all the independent variables are significantly related to Exchange Rate (y) except Inflation Rate (y). In addition, it is concluded that Balance of Payments (x_2) and Import (x_6) are the significant predictors in which the model of Multiple Linear Regression was formulated. With these 8 exogenous variables, a Multi-Layer Feed Forward Neural Network model was created. Most importantly, this study was able to forecast the future values of exchange rate accurately given the use of the Best fitted model which is the Multi-Layer Feedforward Neural Network model. Furthermore, it is concluded that there's a high exchange rate in the near future therefore the government must be aware in order to control the sink

of dollar vs. peso exchange rate since a high exchange rate is not good in a country.

The researchers want to recommend to use the Multi-Layer Feed Forward Neural network rather than Multiple Linear Regression in terms of forecasting since it can make a realistic prediction. It is proven by this study that Multi-Layer Feed Forward Neural Network has a more accurate results for having a low errors using the measurement accuracy.

References

- Department of Economic Research, the Exchange Rate 2018
<http://urbannarc.blogspot.com/2007/12/philippines-peso-best-performing.html>
<https://www.senate.gov.ph/publications/ER%20200802%20-%20The%20Philippine%20Economy%20in%202007%20and%20Prospects%20for%202008.pdf>
<https://www.rappler.com/business/211334-weak-philippine-peso-13-year-low-september-6-2018?fbclid=IwAR2-GSBgCXLGwmxGfDixV-3Lj79qyvotVF1ukutwZmrUH0mrfI-uOOdRhn8>
<https://www.rappler.com/business/211334-weak-philippine-peso-13-year-low-september-6-2018>
 Wei Huang; Kin Keung Lai; Yoshiteru Nakamori; Shouyang Wang , Forecasting Foreign Exchange Rates Using Artificial Neural Networks : A Review
 S. Kumar Chandar (2014), Neural Network Based Forecasting of Foreign Currency Exchange Rates. Retrieved from: <https://pdfs.semanticscholar.org/648e/9b199fec93ce035b4666c720067aef30a094.pdf>
 Bayas, A. C. (2018). Currency Risk Management: Predicting the EUR/USD Exchange Rate. Retrieved from: <https://digitalcommons.wpi.edu/mqp-all/3661>.
 J.Z. Linga, A.K. Tsuia, and Z.Y. Zhangb (2015). Forecast foreign exchange with both linear and non-linear models coupled with trading rules for selected currency. Link: <http://www.mssanz.org.au/modsim2015/>
 Chaudhuri, T.D , Ghosh b, I, Artificial Neural Network and Time Series Modeling Based Approach to Forecasting the Exchange Rate in a Multivariate Framework.(2016)
 D. Ashok Kumar , S. Murugan, Performance Analysis of MLPFF Neural Network Back Propagation Training Algorithms for Time Series Data.(2014) Retrieved from : <https://ieeexplore.ieee.org/document/6755117>
 Vincenzo Pacelli, Vitoantonio Bevilacqua, and Michele Azzollini, An Artificial Neural Network Model to Forecast Exchange Rates
 S. Kumar Chandar, M. Sumathi , S. N. Sivanandam, Foreign Exchange Rate Forecasting using Levenberg-Marquardt Learning Algorithm(2016).
 Ismail, M., Jubley, N. Z., & Mohd Ali, Z. (2018). Forecasting Malaysian foreign exchange rate using artificial neural network and ARIMA time series. In S. M. Zin, N. A. Rusdi, K. A. B. M. Khazali, N. Abdullah, N. Roslan, N. A. M. Zain, R. M. Saad, ... N. M. Yazid (Eds.), Proceeding of the International Conference on

- Mathematics, Engineering and Industrial Applications 2018, ICoMEIA 2018 (Vol. 2013). [020022] American Institute of Physics Inc.. <https://doi.org/10.1063/1.5054221>
- Nanthakumaran, P. and Tilakaratne, C.D., 2018. Financial Time Series Forecasting Using Empirical Mode Decomposition and FNN: A Study on Selected Foreign Exchange Rates. *International Journal on Advances in ICT for Emerging Regions (ICTer)*, 11(1), pp.1–12. DOI: <http://doi.org/10.4038/icterv11i1.7194>
- Cagatay Bal, Serdar Demir, Cagdas Hakan Aladag. A Comparison of Different Model Selection Criteria for Forecasting EURO/USD Exchange Rates by Feed Forward Neural Network(2016). Retrieved from : http://iieng.org/images/proceedings_pdf/U0616010.pdf
- Baranwal, S.K. Multiple Linear Regression Analysis on FDI and Foreign Exchange Rate (2017) Retrieved from : <https://www.scribd.com/document/364876883/Multiple-Linear-Regression-Analysis-on-FDI-and-Foreign-Exchange-Rate>
- J.Z. Linga, A.K. Tsua , Z.Y. Zhangb. Forecast foreign exchange with both linear and nonlinear models coupled with trading rules for selected currencies (2015) Retrieved from : <https://www.mssanz.org.au/modsim2015/E7/ling.pdf>
- Bouraouia, T. , Phisuthtiwatcharavongb, A. On the Determinants of the THB/USD Exchange Rate (2015) Retrieved from :<https://www.sciencedirect.com/science/article/pii/S2212567115012770>
- Usman, O. Phd. Adejare, A. T. Effect of Exchange Rate Volatility on Nigeria Economy (1991-2010) (2013) Retrieved from : [http://hrmars.com/hrmars_papers/EFFECTOF_EXCHANGE_RATE_VOLATILITY_ON_NIGERIA_ECONOMY_\(1991-2010\).pdf](http://hrmars.com/hrmars_papers/EFFECTOF_EXCHANGE_RATE_VOLATILITY_ON_NIGERIA_ECONOMY_(1991-2010).pdf)
- Lehner, Z. DETERMINANTS OF EXCHANGE RATE HEDGING: AN EMPIRICAL ANALYSIS OF U.S. SMALL-CAPINDUSTRIAL FIRMS (2011) Retrieved from :http://etd.fcla.edu/CF/CFH0003787/Lehner_Zachary_M_201105_BS.pdf
- Practical Assessment, Research and Evaluation Volume 8. Number 2. January 2002 Retrieved from: <https://pareonline.net/getvn.asp?v=8&n=2>
- <https://www.investopedia.com/terms/m/mlr.asp>
- <https://www.statisticssolutions.com/pearsons-correlation-coefficient/>
- <https://study.com/academy/lesson/pearson-correlation-coefficient-formula-example-significance.html>
- <https://www.itl.nist.gov/div898/software/dataplot/refman1/auxillar/jarqbera.htm>
- <https://www.statisticssolutions.com/assumptions-of-multiple-linear-regression/eved>
- <https://www.investopedia.com/terms/v/variance-inflation-factor.asp>
- Lesson 12: Multicollinearity and Other Regression Pitfalls Retrieved from: <https://newonlinecourses.science.psu.edu/stat501/node/347/>
- <https://www.statisticshowto.datasciencecentral.com/breusch-pagan-godfrey-test/>
- <https://www.investopedia.com/terms/d/durbin-watson-statistic.asp>
- <http://www.math.nsysu.edu.tw/~lomn/homepage/class/92/DurbinWatsonTest.pdf>
- <https://www.mathworks.com/help/deeplearning/ug/multilayer-neural-network-architecture.html?jsessionid=6943a228caa7dfd64bf55631366>
- <https://study.com/academy/lesson/estimation-of-r-squared-variance-of-epsilon-definition-examples.html>
- <https://www.statisticshowto.datasciencecentral.com/rmse/>
- <https://medium.com/human-in-a-machine-world/mae-and-rmse-which-metric-is-better-e60ac3bde13d>
- <https://rem.jrc.ec.europa.eu/RemWeb/atmes2/20b.htm>
- http://www.eumetrain.org/data/4/451/english/msg/ver_cont_var/uos3/uos3_ko1.htm
- <http://www.vanguardsw.com/business-forecasting-101/mean-absolute-percent-error/>
- <https://www.nytimes.com/2007/12/03/business/worldbusiness/03iht-peso.1.8567103.html>
- <https://www.rappler.com/thought-leaders/205170-reason-philippine-peso-weakest-asean>
- <https://psa.gov.ph/-content/-summary-inflation-rep-ort-consumer-price-index-2000100-decembe-r-2008>
- <https://psa.gov.ph/-statistics/survey/-price/-summary-inflation-rep-ort-consumer-price-index-2006100-decembe-r-2017>
- <http://www.bsp.gov.ph/downloads/publications/2009/annrep2009.pdf>
- http://www.bsp.gov.ph/downloads/Publications/2013/BOP_1qtr2013.pdf
- <http://www.bsp.gov.ph/downloads/publications/2007/annrep2007.pdf>
- <https://psa.gov.ph/content/producer-price-survey-june-2008>
- <https://psa.gov.ph/-gsearch?%2F=producers-+price+index+2018>
- <https://psa.gov.ph/-content/-merchandise-export-pe-rformance-may-2009>
- <https://psa.gov.ph/-content/-highlights-philippine--export-and-import-s-tatistics-july-2018>
- <http://www.bsp.gov.ph/downloads/publications/2018/annrep2018.pdf>
- <https://www.bworldonline.com/increase-in-money-supply-slows/>
- <https://psa.gov.ph/-gsearch?%2F=money+sup-ply+december+2016>