An Analysis on Forecasting Inflation Rate in the Philippines: A Recurrent Neural Network Method Approach

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Abstract: Inflation rate is the proceeding rise within the common level of costs of products and services in an economy over a certain span of time. In 2018, the Philippines has the highest inflation rate among the 10 South East Asian countries. The objective of this research is to forecast the inflation rate of the Philippines for the next five years (2019-2023). Also, the researchers compared the results obtained from the Multiple Linear Regression and Recurrent Neural Network (RNN) performed in MATLAB to determine which of these two models will be the better model in forecasting inflation rate. In this study, the researchers observed the behavior of the Inflation Rate(y) and its economic factors such as Import (x1), Export (x2), Money Supply (x3), Gross Domestic Product (x4), Gross National Product (x5), Expenditure (x6) and Exchange Rate (x7). Using Multiple Linear Regression, this study determined that the significant predictors are Money Supply (x3) and Expenditures (x6). By evaluating the forecast efficiency of the two methods, the researchers concluded that Multilayered Recurrent Neural Network outperforms Multiple Linear Regression in predicting inflation rate of the Philippines. This paper can be useful to the Philippine Government on their decisions about monetary policy making since forecasting the inflation rate has a huge importance and impact in conducting monetary policy..

Keywords: Inflation Rate, Multiple Linear Regression, Forecasting, Multi-Layered Recurrent Neural Network and MATLAB.

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1. Introduction

The proceeding rise within the common level of costs of products and services in an economy over a certain span of time is called Inflation Rate. [1] When this rate goes up, the price of goods and services increases and value of money decreases.

Despite the slump in the world economy and devastation left by natural calamities, Philippines ended 2013 well-with the full fear inflation of 3.0%, not exceeding the Central Bank of the Philippines' target of 3.0% to 5.0%. On the same year, Philippines also got the second spot on the highest GDP growth of 7.2% among the ASEAN countries. However, peso depreciates by 2.5% during the same year as well as the export that failed to reach the full year growth target of 10%. [2] In the year 2017, inflation rate has an average of 3.2% which is much higher than 1.8% average in 2016. On the other hand, Philippine peso depreciated against the US dollar by 5.78% and among other ASEAN countries, peso weakened the most. The total expenditure during the same period amounted to Php 2.49 trillion which is lower than the expenditure target. Also, export and import both posted a growth rate of 19.2% and 17.6% respectively. [3] Inflation rate rose from 6.4% on the end of 2017 to 6.7% in September 2018 according to Philippines Statistic Authority, also, it is the highest rate for the past 9 years due to the fact that at the same year, exchange rate declined from 1.24% to 7.57% and export of goods decreases by 1.2% but import grew by 19.6%. [4]

On this matter, the scientific prediction for inflation rate plays a significant role in preparing future and can serve as a decision-making basis. In this paper, the Multiple Linear Regression and Recurrent Neural Network (RNN) results will be compared to know which is the better predictor, and aims to model long-term behavior of Philippines' Inflation rate from December 2018 to December 2023.

1.1. Objective of the Study

This study aims to show the behavior of the economic predictors of inflation rate such as Import, Export, Money Supply, Gross Domestic Product, Gross National Product, Expenditures and Exchange Rate from January 2007 to November 2018. This study also intend to determine which among the economic predictors have a notable relation to the inflation rate and among these, which are the significant predictors of inflation rate in order to

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obtain a Multiple Linear Regression Model. In addition, this research intends to discuss the better model between Multiple Linear Regression (MLR) and Recurrent Neural Network (RNN) to forecast the monthly inflation rate of the Philippines from December 2018 to December 2023.

1.2 Conceptual Framework

The framework below represents the flow of this study. It includes the data of independent and dependent variables as input and by performing Multi Linear Regression and Recurrent Network, this study will come up on which of the two methods performs better and the intended forecasted values of independent variable.
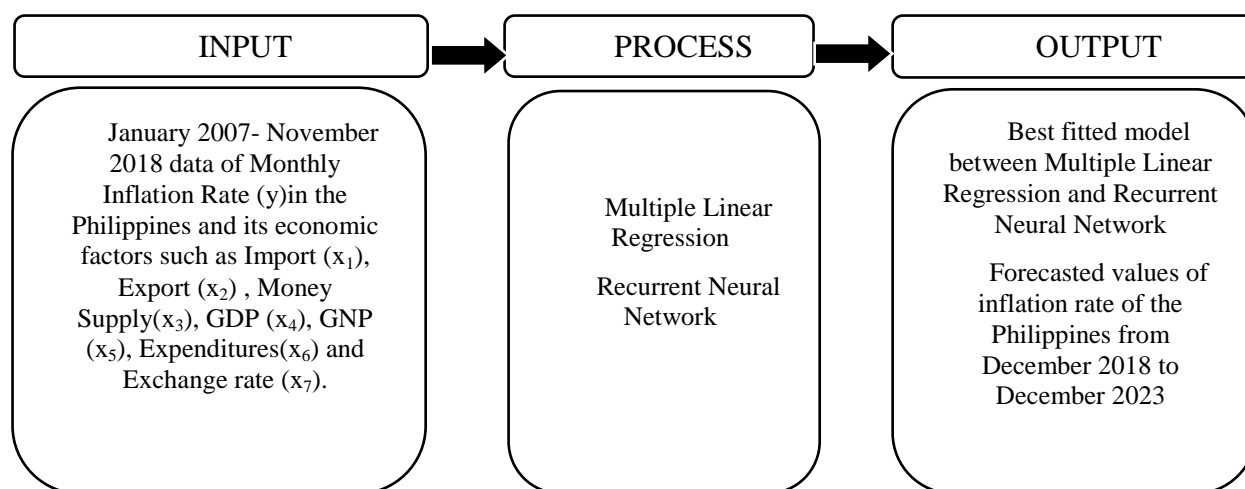
INPUT	PROCESS	OUTPUT
January 2007- November 2018 data of Monthly Inflation Rate (y)in the Philippines and its economic factors such as Import (x_1), Export (x_2) , Money Supply(x_3), GDP (x_4), GNP (x_5), Expenditures(x_6) and Exchange rate (x_7).	Multiple Linear Regression Recurrent Neural Network	Best fitted model between Multiple Linear Regression and Recurrent Neural Network Forecasted values of inflation rate of the Philippines from December 2018 to December 2023

Figure 1.1. A conceptual framework for the study of forecasting inflation rate in the Philippines.

1.3 Statement of the Problem

The purpose of this research is to answer the subsequent questions:

1.3.1 What is the behavior of the graphs of the Inflation Rate (y) in the Philippines and the independent variables which are Import (x_1), Export (x_2), Money Supply (x_3), GDP (x_4), GNP (x_5), Exchange Rate (x_6) and Expenditure (x_7) from year 2007 to 2018?

1.3.2 Is there a significant relationship between Import (x_1), Export (x_2), Money Supply (x_3), GDP (x_4), GNP (x_5), Expenditure (x_6) , Exchange Rate (x_7) and the

Inflation Rate (y) in the Philippines?

1.3.3 Which are the significant predictors of Inflation Rate (y) among the Import (x_1),

Export (x_2), Money Supply (x_3), GDP

(x_4), GNP (x_5), Expenditure (x_6) and

Exchange Rate (x_7)?

1.3.4 What is the Recurrent Neural Network model?

1.3.5 What is the forecasted monthly Inflation Rate (y) in the Philippines from January 2019 to December 2023?

1.4. Scope and Limitations of the Study

This study considered Import (x_1), Export (x_2), Money Supply (x_3), GDP (x_4), GNP (x_5), Expenditures (x_6) and Exchange Rate (x_7) as economic predictors of Inflation Rate (y) of the Philippines using the monthly data set from January 2007 to December 2018 that were obtained from the Philippine Statistics Authority (PSA). This study only focuses on determining predicted values of inflation rate of the Philippines from December 2018 to December 2023 using Multiple Linear Regression (MLR) and Recurrent Neural Network (RNN) and aims to determine which of the two methods perform better.

1.5. Significance of the Study

Determining Inflation rate within the Philippines encompasses a tremendous significance and affect to the conduct of money-related arrangements. Since money-related approach transmission is related with noteworthy slacks and central banks pointing to realize cost soundness ought to be forward looking in their choices as well which underscores the importance of determining inflation rate. Thus, the arrangements of desires are central to

the address of what drives and anticipate inflation but also to policy making.

2.Review Of Literatures And Studies

In the study by M. Rehman, G. Muhammad Khan and S. A Mahmad (2014), used Cartesian Genetic Programming(CGP) and Recurrent Genetic Programming evolved Artificial Neural Network (RCGPANN) was demonstrated to produce a result that is efficient and accurate model for forex prediction with an accuracy as high as 98.872% for a period of 1000 days. The model was evaluated using statistical and then compared. The result also shows that the accuracy increases with expand in variety of feedback path. The neural network model that implements feature selection is consequently a good candidate for foreign exchange prediction. [5]

A study by Paolo Tenti forecasted the exchange rates with the used of recurrent network. The author was able to devise and optimized a trading strategy for the three different recurrent architectures in terms of predicting the accuracy of the Deutsche currency. [6]

In the studyby V.V. Kondratenko and Yu. A Kuperin, showed that the Recurrent Neural Network are able to give forecast with coefficient of multiple determination not worse than 0.65 linear and nonlinear statistical data of the exchange rates of American Dollar and from other major currencies, Japaneses Yen, Swiss Frank, British Pound and Euro. [7]

The study of Gustaf Tegner, entitled "Recurrent neural Network for Financial Asset Forecasting" shows that the RNN provide superior predictive performed compared to Feed-forward networks both when evaluating the sharpe-ratio and accuracy. The results show significant improved performance compared to a set of simple benchmarks. [8]

A study of Sarimah Omar Gan and SabriAhmad,used Multiple Linear Regression to create a regression model and determined the significant predictors to forecast the balance of trade. [9]

In the study by Zhana et. al, introduced a different framework based on Recurrent Neural Networks (RNN). They also established that the framework primarily based on RNN directly models the dependency on user's sequential behaviors into the click prediction method through the recurrent structure in RNN. The results additionally exhibit that the use of RNN can notably improve the click on prediction accuracy.[10]

Petrosian et. al used Recurrent Neural Networks (RNN) with signal wavelet decomposition to predict the asset of epileptic seizure. The result showed that it is quite feasible in the existence of preictal stage of some minute's duration. [11]

A paper by Elsiddig Idriss Mohamed investigated the problem of inflation in Sudan by adopting a Multiple Linear Regression model of analysis based on descriptive economic framework and suggests that the Multiple Linear Regression model is the best tool for evaluation of inflation in Sudan. They also determined which of the economic factors has positive and significant correlation between inflation and found out that that Money Supply and Exchange Rate are those factors. While the factors that has negative correlation between inflation rate in Sudan is Gross Domestic Product. [12]

In the study by Haragopal V. et. al, used the two neural network models which are the Backpropagation Neural Network (BPN) and Recurrent Neural Network (RNN) under static and dynamic forecasts respectively were used to forecast the inflation rate. The result showed that RecurrentNeural Network model under the dynamic forecast is more accurate to use in forecasting inflation rate than the Backpropagation Neural Network model. [13]

Sanju Singh Saini, Omkar Parkhe and Prof. T. D. Khadtare (2016) conducted a study about a comparison of Feed-forward and Recurrent Neural Network for predicting the exchange rate. According to the study, both the neural networks performed well on forecasting exchange rate. However, on the final result, it turned-out that the recurrent neural network gave a better result than the feed-forward neural network. [14]

In the study of A. Adebayo and I. Suleman (2017) investigated the variables that affect inflation of food in Nigeria using Principal Component Regression (PCR) and Multiple Linear Regression (MLR) . The study concluded that the MLR models is a poor predictor of consumer price index in the presences of crude oil and exchange rate and money supply. Also, the study was able to determine that PCR model performs better than MLR models. [15]

A study of E. Falnita and C. Sipos (2007), concluded that the inflation rate in Romania is very strong influenced by thevariations of independent factors from the multiple linear regression models. [16]

A study by Dematos et. al, examined which among the traditional ARIMA, Feedforward and Recurrent Neural Network (RNN) are performed better in forecasting. The results showed thatFeedforward model is relatively accurate in forecasting both price levels and price direction. Also, the researchers found out that the forecast

performance of RNN model is lower than the Feedforward model, but both Feedforward and RNN performed better than the ARIMA benchmark model. [17]

The study by Umut Ugurlu, Oktay Tas and Ilkay Oksuz entitled "Electricity Price using Recurrent Neural Networks" stated that the Recurrent Neural Network set the state of art in addressing time dependent problems and produces a superior performance to various neural network-based methods. [18]

In the study of D. Brezak et. Al, the authors concluded that RNN was more accurate than the Feedforward Neural Network in all tests using a smaller number of hidden layer neurons. [19]

3.Methodology

3.1.Statistical Methods

The statistical models used in this study were Pearson r Correlation, Multiple Linear Regression and Recurrent Neural Network.

3.1.1.Pearson's Correlation Coefficient

Pearson's Correlation Coefficient measures the statistical relationship or association between two continuous variables. It is known to be the foremost method in measuring association between variables of interest since it is based on the method of covariance.

The mathematical formulae r is given as:

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

where n is known to be the number of pairs of scores, $\sum xy$ is the sum of the products of paired scores, $\sum x$ is the sum of the x scores, $\sum y$ is the sum of the y scores, $\sum x^2$ is the sum of the squared x scores and $\sum y^2$ is the sum of the squared y scores. The coefficient (r) ranges from -1 to 1 .If quantity $r = -1$ then the data lie on a straight line with a negative slope; if quantity $r = 0$ then there is no linear relationship between the variables; and if quantity $r = 1$, then the data lie on a straight line with a positive slope. If the scatter points are nearer to a straight line then, the higher the strength of association between the two variables. [20]

3..1.2.Multiple Linear Regression

Multiple linear regression is used to explain the relationship between the inflation rate and its seven economic factors and how these factors can affect the inflation rate in the country. The model below expresses the value of the inflation rate as a linear function of the seven economic variables and an error which is written in the general form:

$$y_1 = b_0 + b_1 x_{1i} + b_2 x_{2i} + b_3 x_{3i} + \dots + b_k x_{ki} + e_i$$

where y_i is the is the predictand in year i, b_0 is the regression coefficient, b_k is the coefficient on the kth predictor, x_{ik} is the value of kth predictor in year i, e_i is the error term and k is the total number of predictors.

The following are the assumptions underlying Multiple Linear Regression:

Linearity

The relationship of independent variables (x_i) and dependent variable (y) should be linear. It is necessary to check the linearity among the variables using the Pearson's Correlation Coefficient. For the formula and statistical hypotheses, one can refer on section 3.1.1. [20]

Normality

The Jarque-Bera Test is accustomed to establish whether the residuals of the sample data are normally distributed. It is based on the maximum difference between the observed distribution and expected cumulative-normal distribution. It is defined as:

H_0: The data is normally distributed.

H_a: The data is not normally distributed.

The formula is given as:

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

where n is known to be the sample size, s is the sample skewness coefficient and k is the sample kurtosis coefficient. A large J-B value indicates that errors are not normally distributed. [21]

Multicollinearity

Multiple Linear Regression uses an assumption that the variables are not highly correlated with one another. It is used to describe the relationship among continuous dependent variable and two or more independent variables.

In this study, Variance Inflation Factor (VIF) will be used to verify multicollinearity assumption. VIF evaluates how much the fluctuation is inflated. As long as the VIF is under 10, the conducted regression should be fine, where there is no multicollinearity between the independent variables.

The formula is given as:

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

where R_k^2 is the R^2 – 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. [22]

Homoscedasticity

The Breusch-Pagan-Godfrey Test is a test used for heteroscedasticity of errors in regression. Heteroscedasticity refers to a condition in which the variability of variable is unequal or not constant across the range of values of a second variable that predicts it. The test statistic for the Breusch-Pagan-Godfrey test is

$$N * R^2 \ (with\ k\ degrees\ of\ freedom)$$

where n is known to be the sample size, R^2 (<u>Coefficient of Determination</u>) of the regression of squared residuals from the original regression and k is the number of <u>independent variables</u>.

This test statistic normally follows a chi-square distribution. Note that Breush-Pagan test calculates how blunders increment over a certain variable, Y. The test assumes that the error fluctuations are caused by linear function of one or more variables in the model. Meaning, heteroscedasticity seems still be display in the regression model, but those errors (in the event that show) are not related with y-values. [23]

The test hypotheses are:

H_0: The residual squared of the data is homoscedastic.

H_a: The residual squared of the data is heteroscedastic.

Independence

For Multiple Linear Regression, the residuals must be independent. For this study, Durbin-Watson Test was used to check the Independence of dependent variable from the independent variables. The Durbin-Watson statistic ranges in value from 0 to 4 where a value 2 means no presence of auto-correlation; a value less than 2 means positive autocorrelation exists and a value greater than 2 means negative autocorrelation exists. The hypotheses for the Durbin-Watson Test are:

$$H_0: \rho = 0$$
$$H_a: \rho > 0$$

The test statistic is:

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

where $e_i = y_i - \hat{y}_i$, y_i and $\hat{y}_i$ are the observed and predicted values of the response variable for the individual i, respectively, d becomes smaller as the serial correlations increase. [24]

3.1.2. Multi-Layer Recurrent Neural Network

A Recurrent Neural Network (RNN) is essentially a sort of progressed artificial neural network (ANN) that includes coordinated cycles in memory. Recurrent Neural Network has a capacity to construct on prior sorts of systems with fixed-size input and yield vectors. RNN has been a dynamic region of center of numerous experts for employments like image processing and language processing.
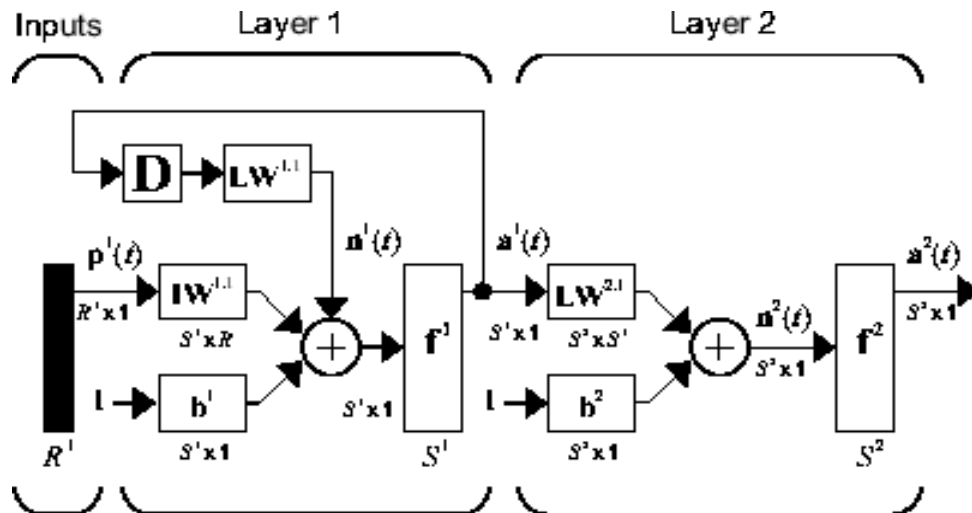
The diagram 3.1 displays the resulting network diagram, wherethere is a feedback loop, with a single delay, around each layer of the network except for the last layer. The LRN layouts are used in many filtering and modelling applications. The toolbox trains the LRN using exact versions of the gradient-based algorithms. [25]

3.1.3.Measurements Accuracy

In this study, we will use five different measurements accuracy such as Mean Square

Error, Root Mean Square Error, Normalized Mean Square Error , Mean Absolute Error and Mean Absolute Percentage Error. These measurement accuracies are used during the training of the model.

Mean Squared Error (MSE)

The Mean Squared Error is the average of the squared errors between actual and forecasted readings in a data sample. Squaring is necessary to remove any negative signs. The smaller value of means squared error, the closer you are to finding the line of best fit. [26]

$$MSE = \left(\frac{1}{n}\right)\sum_{t=1}^{n}(yp_t - yo_t)^2$$

Root Mean Square Error (RMSE)

Root Mean Square Error is the standard deviation of the residuals. It's the square root of the average of squared differences between prediction and actual observation. [27]

$$RMSE = \sqrt{\left(\frac{1}{n}\right)\sum_{i=1}^{n}(yp_i - yo_i)^2}$$

Normalized Mean Square Error (NMSE)

NMSE is an estimator of the overall deviations between predicted and measured values.

$$NMSE = \frac{1}{n}\sum_{i}\frac{(yp_i - yo_i)^2}{\bar{P}\bar{M}}$$

where $\bar{P} = \frac{1}{n}\sum_i yp_i$ and $\bar{M} = \frac{1}{n}\sum_i yo_i$. [28]

Mean Absolute Error (MAE)

Mean absolute error measures the average magnitude of the errors in a set of forecasts, without considering their direction.The mean absolute error is the average over the verification sample of the absolute values of the differences between forecast and the corresponding observation. [29]

$$MAE = \left(\frac{1}{n}\right)\sum_{i=1}^{n}|(yp_i - yo_i)|$$

Mean Absolute Percentage Error

Mean absolute percentage error is a statistical measure how concise a forecast system is. It measures this accuracy as a percentage and can be calculated as the average absolute percent error for each time period minus actual values divided by actual values.

$$MAPE = \left(\frac{1}{n}\right) \sum_{i=1}^{n} (|PE_t|)$$

where $PE_t = \left[\frac{yp_t - yo_t}{yo_t}\right] * 100$. [30]

4. Results and Discussion

4.1. Behavior of Graphs

The following figures are the graphs of Import (x_1), Export (x_2), Money Supply (x_3), Gross Domestic Product (x_4), Gross National Product (x_5), Expenditures (x_6), Exchange Rate (x_7) and Inflation Rate (y) from year 2007 to 2018.
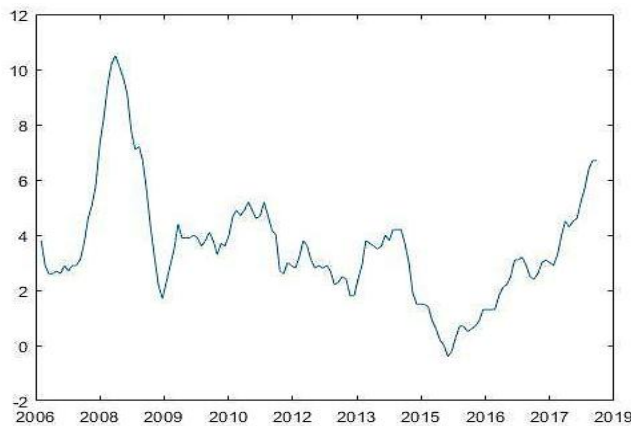
Figure 4.1. Graph of Inflation Rate of the Philippines from January 2017-November 2018
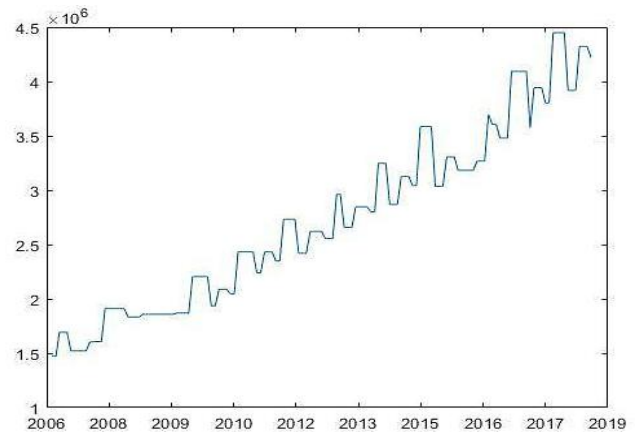
Figure 4.2. Graph of GDP of the Philippines from January 2017-November 2018

In figure 4.1, the graph shown that the highest inflation rate occurred was in the year 2008. According to PSA, in October 2008, the inflation rate reached to 7.25% which was an all-time high record for the past few years. Another factor that contribute to the inflation rate in the year 2008, was the Global Rice Crisis happened which slowed down the economic growth of the Philippines. However, in July 2015, reaches the new 20 years low inflation rate which was due to the decrease in residential retail costs of corn, oil and rice; lower international oil costs; and the withdrawal within the costs of lodging and other utilities. [31]
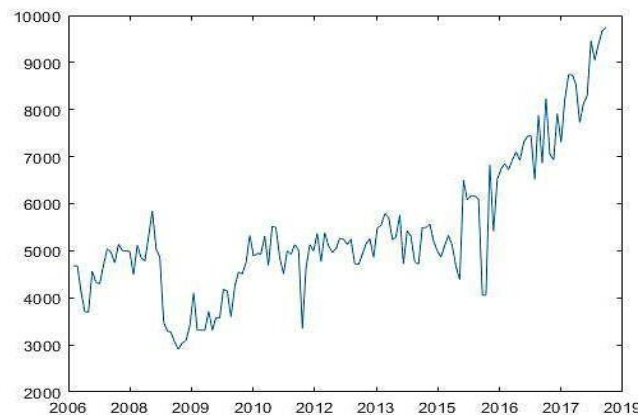

Figure 4.3. Graph of Expenditure of the Philippines from January 2017-November 2018

As shown in Figure 4.2, the GDP of the Philippines is at its peak for the year 2017. According to the Philippine Statistics Authority, agriculture, import and export have a large impact for this growth making the Philippines GDP the 3rd best in Asia after China and Vietnam. [20] At 2018, GDP slightly depreciated, economist say that the rapid movement of inflation rate had a high impact on the downgrade. [32]

In Figure 4.3, notice that from the last quarter of 2017, the government expenditure had a gradual increase of 27% in the first quarter of 2018. The gradual increase was mainly due to the first batch of increase for health insurance premiums of senior citizen. Also, a huge amount was downloaded for the Tax Reform Cash project and P3.4 billion subsidy was given to the National Food Authority for the rice importation program and billion pesos were also given to Subic Bay Metropolitan Authority for the power

subsidy. Infrastructure projects of DPWH were also a big part to the huge increase of government expenditure. [33]

In Figure 4.4, the government reaching an all-time high in the first quarter of 2018 was faster than the growth recorded in the same quarter of 2017. The main reason of growth for the first quarter of 2018 is the manufacturing, other services, and trade.[34]
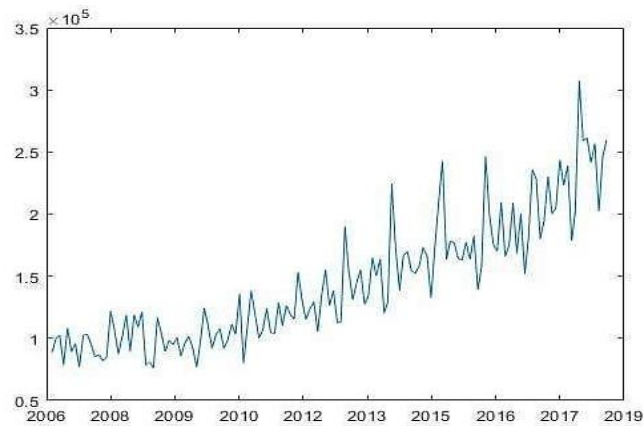

Figure 4.5. Graph of Exchange Rate of the Philippines from January 2017- November2018

in Figure 4.5, Philippine peso depreciated by 5.04% in year 2018 since the import has consistently exceeds the export in that year, also because of the weak remittances and strong capital outflows. On the other hand, Philippine peso appreciate by 19.5% in the year 2007 because of strong real GDP growth of 7.2%, low inflation rate averaging 2.8% and steady export earnings grew by 6.0%. [35]

As shown in Figure 4.6 the money supply in the Philippines dropped in the year 2008 due to the slow economic growth of the Philippines who marked 4.6%, but increased significantly on the 3rd Quarter since of the usage of the framework ventures to moderate financial withdrawal.[36]
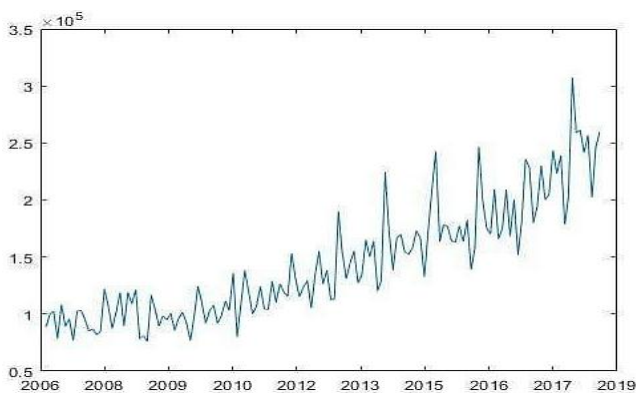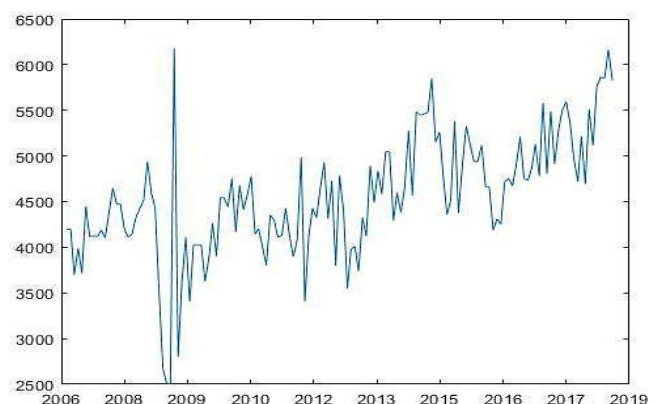
The toughest year of the Philippines is year 2008

Figure 4.7. Graph of Export of the Philippines from January 2017- November 2018

and 2009.

Figure 4.8. Graph of Import of the Philippines from January 2017-November 2018

Because of the uncontrollable effects of financial crisis in global economy, Philippine economy came primarily through the trade channel. Based on Figure 4.7, the full trade decelerated by 10% amid the fourth quarter of 2008 which was lower than 13% recorded within the third quarter of the same year. Year-on-year, from January to September, exporters suffered from a problematic situation of the later worldwide financial subsidence with add up to sends out posting a negative development of 14.2%-- the

negative 1.9 % in 2008 based on the economic report of Senate Economic Planning Office. The weak performance of merchandise exports is one of the reasons why total exports continue to drag.[37]

Philippines' total import in 2018 has an increase of 15.8% from 2017. In 2017, the Philippines total import amounted to $105 billion, making it the 32nd largest importer in the world. During the last five years, the imports of the Philippines have increased at an annualized rate of 7%. Imports for 2011 registered a positive growth of 7.1% from 2010. As for the year 2010, it has a 29% increase from 2009. Year 2009 has a 76.2% of the total import bill, concluding to a 27.5% decrease from the total import of 2008. This declined happened due of the 2008 Global Financial Crisis that caused the collapsed of large institutions around the world. World rice supply crisis also happened this year. Despite of the Philippines being as one of the largest producer of rice in 2008, it was also the world's top rice importer that led the country to be directly affected of the rice crisis. Trade and output growth resumed in the second half of 2009. [38] Imports from 2008 registered a 0.3% increase from 2007 which has 7.1% increase from 2006.

4.1. Significant relationship between the independent variables and Inflation Rate of the Philippines.

4.1.1. Scatter Plot

The following figures are the scatter plot between Inflation Rate (y) and the independent variables which are Import (x_1), Export (x_2), Money Supply (x_3), Gross Domestic Product (x_4), Gross National Product (x_5), Expenditures (x_6), and Exchange Rate (x_7).
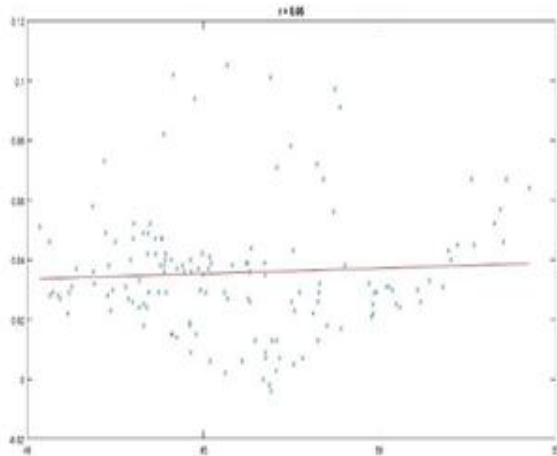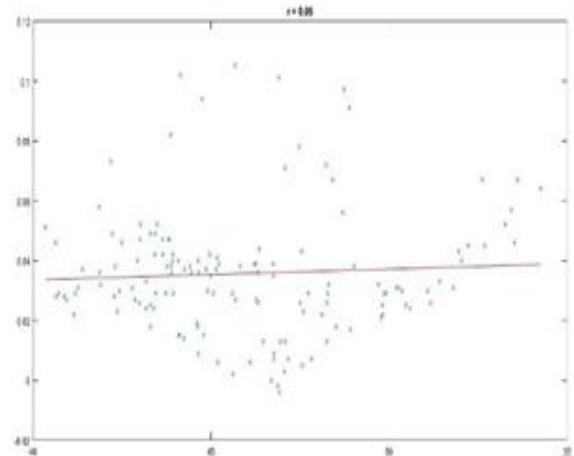

Figure 4.9. Import (x_1) and Inflation Rate (y)
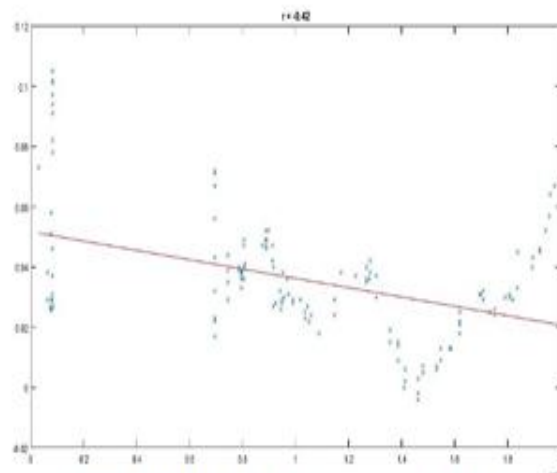

Figure 4.10. Export (x_2) and Inflation Rate (y)

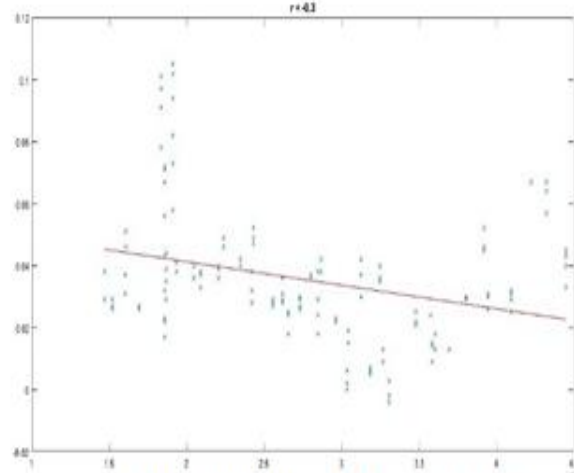**Figure 4.11.** Money Supply (x_3) and Inflation Rate (y)

Figure 4.12. GDP (x_4) and Inflation Rate (y)
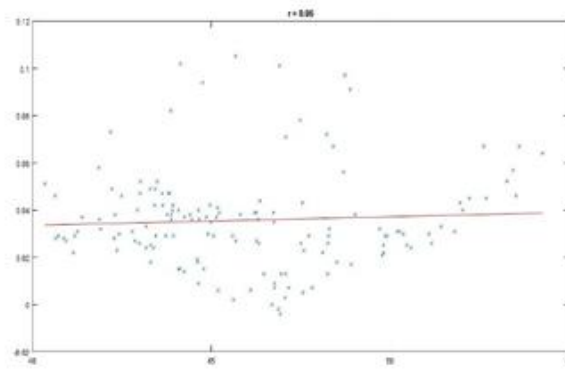
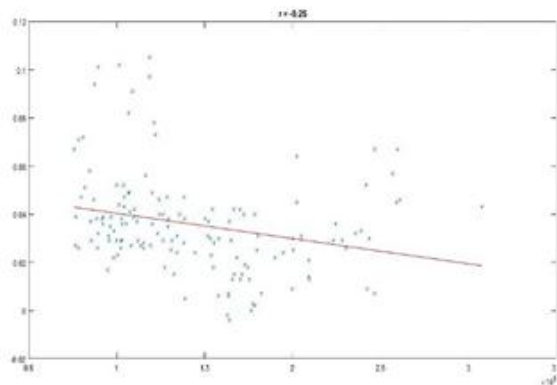**Figure 4.13**. GNP (x_5) and Inflation Rate (y)   **Figure 4.13**. Exchange Rate (x_7) and Inflation Rate (y)
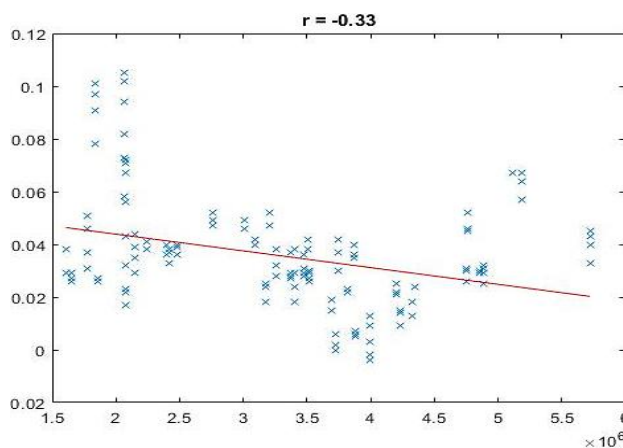

Figure 4.14. Expenditures $(x)_6$ and Inflation Rate (y)

Notice that in the scatter plot showed that in Figures 4.9, 4.10, 4.13 forms a straight line. This means that the correlation between Inflation Rate (y) and Import (x_1), Export (x_2) and Exchange Rate (x_7) respectively, are weak. Hence, we can say that there is no notable relation between Inflation Rate (y) and Import (x_1), Export (x_2) and Exchange Rate (x_7) respectively. However, in figures 4.11, 4.12 and 4.14, notice that the scatter plot forms a line that is decreasing. This means that the correlation between Inflation Rate (y) and Money Supply (x_3), GDP (x_4) and Expenditures (x_6) are moderately strong. Hence, we can say that there is a notable relation between Inflation Rate and Money Supply (x_3), GDP (x_4) and Expenditure (x_6) respectively.

4.2.2. Pearson r

The table below will indicate which among the independent variables: Import (x_1), Export (x_2), Money Supply (x_3), GDP (x_4), GNP (x_5), Expenditure (x_6), Exchange Rate (x_7) are the significant factors of Inflation Rate (y

Table 4.1. Relationship of Independent Variables to the Inflation Rate (y) of the Philippines

Variables	Pearson r	Verbal Interpretation	p-value	Decision	Remarks
Import (x_1)	-0.0123	very weak negative correlation	0.8839	Failed to reject H_0	Not Significant
Export (x_2)	-0.1166	very weak negative correlation	0.1657	Failed to reject H_0	Not Significant
Money Supply (x_3)	-0.4117	moderately strong correlation	0.00	Reject H_0	Significant
		weak negative		Reject Ho	Significant

GDP (x_4)	-0.3005	correlation	0.0003		
GNP (x_5)	-0.3316	weak negative correlation	0.0001	Reject H_0	Significant
Expenditures (x_6)	-0.255	weak negative correlation	0.0021	Reject H_0	Significant
Exchange Rate (x_7)	0.0575	very weak correlation	0.4951	Failed to reject H_0	Not Significant

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. p-value 0.05. Reject H_0 if $p< 0.05$ and failed to reject if $p\geq 0.05$.

From Table 4.1, the p-value of GDP (x_4), GNP (x_5), Money Supply (x_3) and Expenditures (x_6) are less than the level of significance which means we reject the null hypothesis. Thus, the only factors of inflation rate that have a significant relationship are Money Supply (x_3), GDP (x_4), GNP (x_5) and Expenditures (x_6).

4.3. Significant Predictors of Inflation Rate
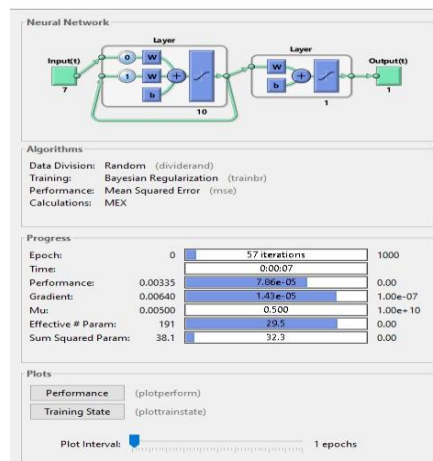
Multiple Linear Regression Model

Table 4.2. Regression analysis

Variables	Beta parameter	p-value	Decision
Constant	0.043192	0.0000	Reject Ho
Money supply (x_3)	0.000000 12677	0.02604	Reject Ho
Expenditure (x_6)	-0.00000 24992	0.0000	Reject Ho

Linear Regression Model: $y = 0.043192 + 0.0000001267x_3 - 0.00000249x_6$

Table 4.2 displays that among the seven controlled variables; the only significant predictors are money supply(x_3) and Expenditure (x_6) with the p-values of 0.02604 and 0.0000 respectively. After testing the four assumptions in multiple linear regression, specifically Pearson r for linearity show that the GDP (x_4), GNP (x_5), money supply(x_3) and Expenditure (x_6) have a notable relation to the Inflation rate. Second, the variance inflation factor states that money supply(x_3) and Expenditure (x_6) are highly correlated with each other. Jarque bera was used to test the normality of the model, residuals are normally distributed having a p-value of 0.5000. Using Breusch, 0.10 was the obtained p-value of the residual squared of money supply(x_3) and Expenditure (x_6) making it homoscedastic.   For every 0.00000249 decrease in Expenditures (x_1) there is also a decrease in Inflation rate (y) assuming all variables are constant and for every 0.0000001267 increase in Money Supply (x_2) , then there is also an increase in Inflation rate (y) assuming all variables are constant.

4.3.1. Actual vs. Predicted

Figure 4.17 displays the graph of Actual vs Predicted Inflation rate for the year 2007- November 2018. Using Multiple Linear Regression Method, it was observed that there is actually a huge difference on some years between the actual figures and forecasted values of Inflation Rate.

4.4. Recurrent Neural Network Model

The figure 4.18 illustrates the training state of the Recurrent Neural Network using the Bayesian Regularization. Training the network used is necessary to generate the Recurrent Neural Network Model.

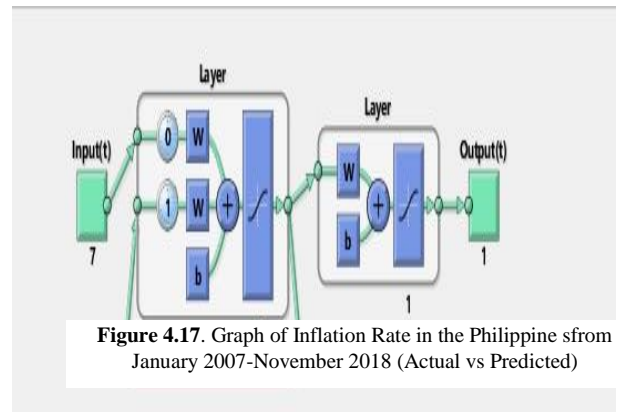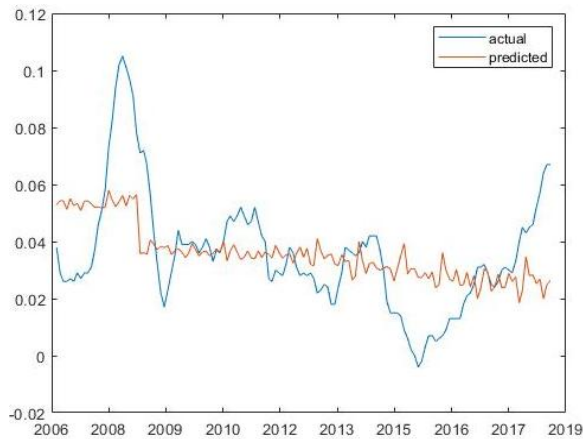**Figure 4.18**. Training the Recurrent Neural Network

Figure 4.17. Graph of Inflation Rate in the Philippine sfrom January 2007-November 2018 (Actual vs Predicted)

Figure 4.19. Recurrent Neural Network Model

The recurrent neural network model above shows that there are seven inputs which are the economics predictors and the target output is the forecasted inflation rate of the Philippines for the next five years.

The figure 4.20 shows the actual and forecasted figures of the Inflation Rate of the Philippines for 2007-2008. The forecasted figures of Inflation Rate were obtained using the Recurrent Neural Network Method.
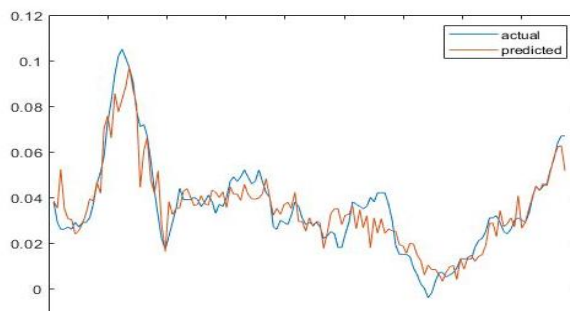

Figure 4.20. Graph of Actual vs Predicted Inflation Rate of the Philippines from 2007-2018.

4.5. Forecasting Accuracy and Forecasted Values

4.5.1. Forecasting Accuracy

Table 4.3. Forecasting Accuracy of Recurrent Neural Network and Multiple Linear Regression

Model	MAPE	MSE	MAE	RMSE	NMSE
MLR	0.5538	0.00034458	0.0186	0.0186	0.00034458
RNN	0.2321	0.00006727	0.0061	0.0082	0.00006727

According to the forecasting accuracy table, Recurrent Neural Network Model (RNN) gives us the least error under Mean Squared Error and the Norm Mean Squared Error with 0.00006727 compared to the computed Mean Squared Error and Norm Mean Squared Error of the Multiple Linear Regression with 0.00034458 for both errors making RNN the better model than Multiple Linear Regression.
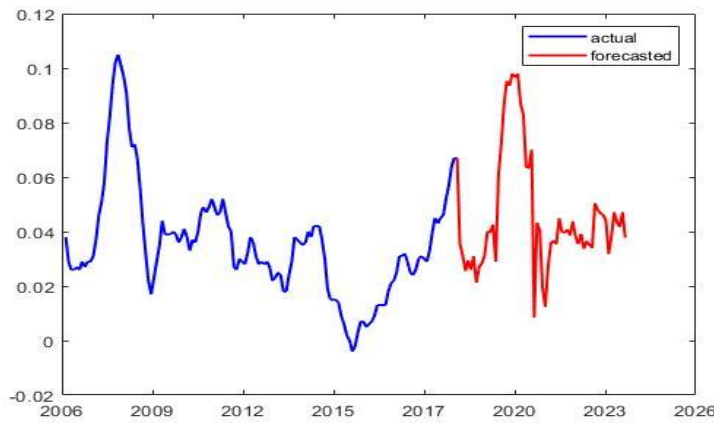
4.5.2.Actual vs. Forecasted

Figure 4.21. Actual vs Forecasted Inflation Rate in the Philippines

Table 4.4: Forecasted Monthly Inflation rate from 2019 to 2024

Month	2019	2020	2021	2022	2023	2024
January	0.035673889	0.042566937	0.063939457	0.044886792	0.034066192	0.037796109
February	0.031208934	0.028992694	0.063361298	0.039872549	0.050399949	0.026459651
March	0.025569355	0.061154968	0.070062241	0.039704699	0.04795835	0.028168719
April	0.029339367	0.071597202	0.008434235	0.040659051	0.046833307	0.029655891
May	0.026041133	0.086474018	0.043221426	0.0386386 1	0.046076976	0.031453087
June	0.030993009	0.095234039	0.040421552	0.043705631	0.044270607	0.032018141
July	0.021238287	0.093543735	0.019242165	0.037970092	0.031707824	0.0384025 5
August	0.026903452	0.097948426	0.012380066	0.035453825	0.038111681	0.035120464
September	0.028381935	0.096704845	0.027166142	0.0391366 8	0.047075134	0.032655541
October	0.031408175	0.097900576	0.035763316	0.033717544	0.043375841	0.031885621
November	0.039901387	0.0870422 5	0.036596744	0.036491423	0.041799425	0.028379706
December	0.0398706 1	0.083107673	0.035406962	0.0351915 3	0.047114575	0.029789286

In figure 4.21, the graph shows the actual (blue lines) and forecasted (red lines) plot of the Inflation rate in the Philippines. It shows that after an increase in the inflation rate in year 2018, the plot fluctuates for the year 2019 then was followed again by the sudden and huge increase in inflation rate for the year 2020. On the following years, the graph shows that the inflation rate in the Philippines shifts frequently.

5,Conclusions and Recommendations

5.1 Conclusion

From the outcome, it is shown that among the seven independent variables only money supply (x_3), Gross Domestic Product (x_4), Gross National Product (x_5) and Expenditures (x_6) were found to have a notable relation to the Inflation Rate of the Phillipines (y) and from these, with the used of Multiple Linear Regression, it was determined that only Money Supply (x_3) and Expenditures (x_6) are the only significant predictors in predicting the

Inflation Rate of the Philippines (y). Also, the researchers compared the forecasting accuracy of Multiple Linear Regression and Recurrent Neural Network and it was found out that the best model used in forecasting Inflation Rate of the Philippines (y) is the Recurrent Neural Network Model. Using the better model which is the Recurrent Neural Network, forecasted values of Inflation Rate of the Philippines (y) for the year 2019-2024 were obtained.

5.2 Recommendation

For future studies, the researchers recommend to use other approaches in predicting and forecasting Inflation Rate of the Philippines. Also, the researchers recommend to use other factors the might really affect the Inflation Rate of the Philippines

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