

A COMPARATIVE STUDY OF EXPONENTIAL AND POLYNOMIAL MODEL FOR PREDICTION OF NAIRA TO DOLLAR EXCHANGE RATE: A MACHINE LEARNING APPROACH

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Abstract

This research work explores the performance of exponential and polynomial models in the prediction of naira to dollar exchange rate on yearly basis, using machine learning approach and compare their performances with each other and with other existing models. It was established that polynomial model predicts the exchange rate better than exponential model and that the polynomial model is better than the existing ones. Again, the polynomial model predicted the exchange rate of naira from 1950 to 2050 on yearly basis and established the fact that by 2050 an American dollar will be equivalent to ₦800. MATLAB was used for the implementation of the models.

Keywords: Exchange rate, Exponential Model, Polynomial Model, Machine Learning, Naira (₦)

1. Introduction

One of the most important yardsticks in measuring the economic viability of any nation is its exchange rate. Exchange rate is the value of a currency when compared with another currency at a particular point in time. The exchange rate of a currency determines its strength which in turn determines the viability of the currency in question. The theory of forecasting has been in existence for many years where different models yield different forecasting results either in sample or out of sample according to [8]. The exchange rate reflects the ratio at which one currency can be exchanged with another currency, namely the ratio of currency prices. It is the value of a foreign nation currency in form of home nation currency and hence specifies how much one currency is worth in terms of the others [9].

The economic situations of a country, its political factors as well as the psychological state of individuals are among the major factors that influence the exchange rate of any country. These factors maintain a certain level of relationship and the way they interact is quite a complex one and those interactions are very unstable, dynamic and volatile. One of the most challenging applications of modern prediction is in the area of exchange rate prediction [1].

Exchange rate forecasting or prediction are inherently noisy, non-stationary and deterministically chaotic. As explained by [5] in [1], it is noisy because of unavailability of complete information or data from the previous financial market to fully capture the dependency between the future and the past prices. Hence, historical data remains the major entity that can be used for prediction using machine learning approach. We are now in the era of big data. Large data are being collected from time to time. This deluge of data calls for automated method of data analysis which is what ML is all about. ML emanated from AI. AI is a branch of Computer Science that makes an attempt to create intelligence (artificial) in machine using computer code to enable the machine to solve real life problems in a humanlike fashion [7].

Machine learning as one of the branches of AI is defined by [3] as a set of method that can automatically detect pattern in data and then use the uncovered pattern to predict the future data or to perform other kinds of decision making under uncertainty. It is the domain of computational intelligence faced with the challenge of how to construct computer programs that automatically

improves with experience. Hence, [11] defined ML as automatic machine learning method. The act of building and using models that can in turn be used to make predictions based on the availability of historical data is the major concern of ML. ML as an aspect of AI has been found to be very useful in virtually all the fields of human endeavour. Hence, it is a very useful tool in the field of Science, Engineering, medicine, Philosophy etc.

In everyday usage, the word “predict” has a specific meaning—we predict what will happen in future. However, in data analysis, a prediction is an assignment of values to any unknown variable. Models are trained to make predictions based on a set of historical data and we use machine learning algorithms to train those models. Therefore, it is quite clear that Learning as a concept is very paramount when discussing the issue of ML. Learning algorithms will be used to train our models. There are three major types of learning. These are supervised, unsupervised and reinforcement.

In supervised learning, there is a mapping from input to output. This means that exact value of output is provided or labeled for each of the input. The labeling is done by the teacher or supervisor (the learning algorithm). So, in supervised learning, there are always some instructions provided by the supervisor to aid the learning process.

Unlike supervised learning, unsupervised learning algorithm is on its own to study the pattern of a given data and make a sense out of it. In fact, certain regularities occur in the structure of the input data which the algorithm studies and come up with a general behaviour of the whole data for further processing. In this type of learning, the learning process is not completely aided by the supervisor but the algorithm struggle on its own to come up with a better solution.

In reinforcement learning, an agent interacts with the environment, learns from its interaction to make future decisions. If the interaction yields positively, the agent receives a reward else the agent is penalized. Example of this interaction is found in autonomous driving system like self-driving cars.

Nigeria is one of the developing countries in the world. In sixty's and seventy's, it was being referred to as the giant of Africa because of the viability of its economy. One of the reasons for its economic viability is the strength of its naira currency which was competing favourably with America currency (dollars) in the world market. Unfortunately, in eighty's, the currency started losing its value. This seriously affects the economy of the country negatively as the value continues to fluctuate from time to time to the extent that a dollar is now equivalent to about ₦350. A lot of research work has been carried out to predict the naira equivalent of other country currency and different methods and approaches have been used. Computer Scientists are not left out in this race. Yet, enough efforts have not been made in the area of using AI to solve this problem. Hence, this research work is out to compare the performance of polynomial and exponential model in the prediction of naira to dollar exchange rate using Machine Learning approach.

2. Statement of the problem

The fluctuation in the value of naira has created a lot of economic instability in Nigeria as it is increasingly becoming difficult for all stakeholders to predict the exchange rate of naira to other currencies. How do we solve this problem? Government at all levels – Local, State and Federal level finds it difficult to formulate good economic policies because of this lingering problem. For the same reason, industries, manufacturing companies, parastatals are running their businesses at loss, foreign investors are discouraged from investing their businesses in Nigeria. In actual fact, this situation produces a very negative effect on the development of Nigeria economy.

3. Literature review

[8] forecasted the exchange rate between naira and US dollars between January 1994 and December 2011 using ARIMA model. They were able to predict that naira will continue to depreciate. The prediction is on monthly basis and not on yearly basis. The method used was statistical and has nothing to do with machine learning approach

[9] also used ARIMA model to forecast the exchange rate between naira to dollar between January 2011 to December 2014. It was concluded that naira will not have major fluctuation with exchange rate of one hundred and fifty naira, fifty-one kobo (₦150.51k) between January, 2012 to December 2014. The model did not use any machine learning predictive model but rather a statistical model was adopted.

[11] looked at the volatility of exchange rate of naira to other major currencies using GARCH (1, 1) and its asymmetric variation. The article concluded that majority of the parameters are significant and volatility is quite persistent. ML algorithm was not used but rather a statistical approach was adopted.

[6] also used ARIMA model and revealed that the exchange rate of naira to a US dollar has been relatively stable from 1972 to 1985. The exchange rate of naira to US dollar was forecasted for a period of 6 years and this shows that naira will continue to depreciate in relation to US dollar within the period forecasted. Authors did not, however use machine learning approach.

[2] modeled dollar – naira exchange rate and concluded that ARIMA is the best method for modeling the exchange rate

[13] develop an algorithm to predict the exchange rate of £ to US dollar up to 3 days ahead of last data available using neural network. The authors though used a machine learning approach but the prediction will be of the last 3 days ahead of available data and not on yearly or monthly or yearly basis.

[14] also carried out a review on forecasting foreign exchange rate with artificial neural network. It was a review and therefore quite different from our own research work.

[1] also used artificial NN model to forecast foreign exchange market. Though the author used AI approach but the research work has nothing to do with polynomial or exponential models.

[4] also used NN to forecast foreign currency exchange rate using algorithms. The 5 different training system was packaged enough to produce more accurate powerful algorithm. The model was trained using historical data to predict 4 – foreign currency exchange rate against India currency (Rupees). The author confirmed that it was an improved technique to forecast foreign exchange rate. The research work has nothing to do with exponential and polynomial model.

4. Methodology and Discussion of Result

This research work looks into the exchange rate of naira to dollar using machine learning approach. In the research, we used two different models - polynomial and exponential. With the same set of historical data, both the polynomial and exponential model shows the same trend but their extrapolation into the future shows that the exponential model shows greater growth than the polynomial model

An exponential model with a single variable is of the form:

$$\hat{y} = y_0(g)^{t/c} \text{ where} \tag{1}$$

\hat{y} is the predicted value of naira to dollar as at time t,

y_0 is the initial value of naira to dollar,

g is the growth factor i.e. increase in the value of naira compared to dollar,

t is the elapsed time,

c is the time taken for g to occur.

If $g > 1$ there is an exponential growth but if $0 < g < 1$, there is exponential decay.

For Polynomial Model on the other hand, the predicted value of y in multivariate regression can be depicted as:

$$(\hat{y}) = a_0 + a_1 x_1 + \dots + a_n x_n^k \tag{2}$$

In compact form:

$$\begin{aligned} \text{sum} &= 0 \\ \text{for } i &= 0, 1, \dots, n: \\ \text{for } j &= 0, 1, \dots, k: \\ \text{sum} &= \text{sum} + a_j x_j^i \end{aligned}$$

$$(\hat{y}) = \sum$$

where

(\hat{y}) is the predicted value of dollar

n is the year

k is the non-negative integer representing the degree of polynomial $\in k > 1$

a_i represents coefficients ($i = 0, 1, \dots, n$)

x_i represents the predictors of (\hat{y}) i.e. Nigeria naira (₦) in a particular year

Figure 1 shows the historical naira to dollar exchange rate. Between 1950 and 1985, the exchange rate was practically constant i.e. the value of naira to dollar is almost the same at an average of 0.71 naira to one dollar. This is due to the fact that the economic situation of the Nigeria then was relatively stable. In 1986, it was ₦1.75 naira to 1 USD and since then, it has been on the increase side. This is expressed in figure1.

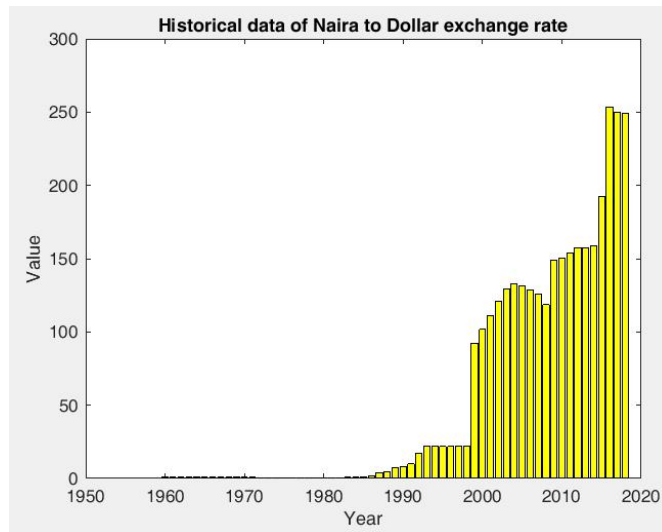


Fig1: Historical data of dollar to Naira Exchange Rate

During the research work, different models were obtained out of which the best was picked. Figure 2 shows one of the models obtained (a trial version), though not the best since there is a significant difference between the actual and the predicted values. Hence, the modeling curves and the actual curves are not at pal.

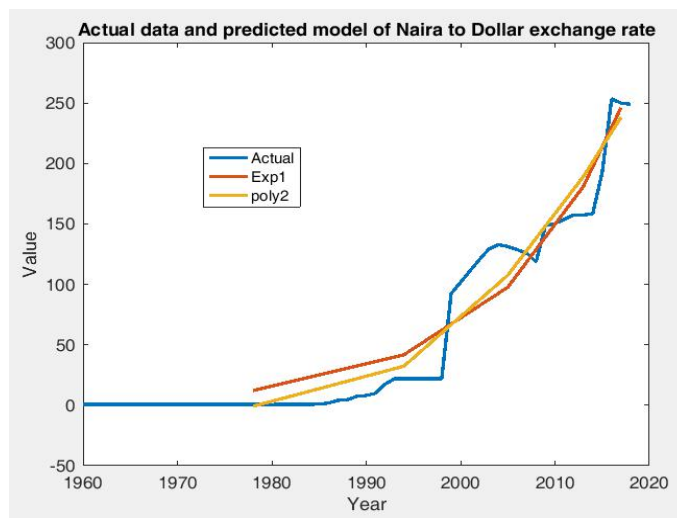


Fig 2: Actual versus Predicted Model of Naira to Dollar Exchange Rate (Trial version)

Fig 3 shows the best models out of all the models obtained. It is quite obvious that both the actual and the predicted model almost coincide with each other between the year 1960 and the year 2019. In fact, the error values appear to be quite insignificant. This is an indication that the performance exhibited by the models as shown in figure 3 is the best that could be obtained for the purpose of this research work. However, it was observed that the exponential model (2) shows higher growth than the polynomial model (2) between the year 2020 and the year 2050. It appears from the figure that polynomial model will be a better predictor of the naira to dollar exchange rate. It was further observed that the extrapolation into the future of the two models shows that the exponential model produced an outrageous value whereas the polynomial model produced a better result.

At the prediction level between 2020 to 2050, the behaviour of the exponential model seems to be quite abnormal as it predicts the values of naira to dollar in 2050 to be ₦3,000 but the prediction of polynomial model appears to very reasonable as it predicted the value of naira to dollar to be ₦800 in 2050. The analysis again clearly shows that the extrapolation of the polynomial model follows the actual trend whereas extrapolation of the exponential model deviated from the trend.

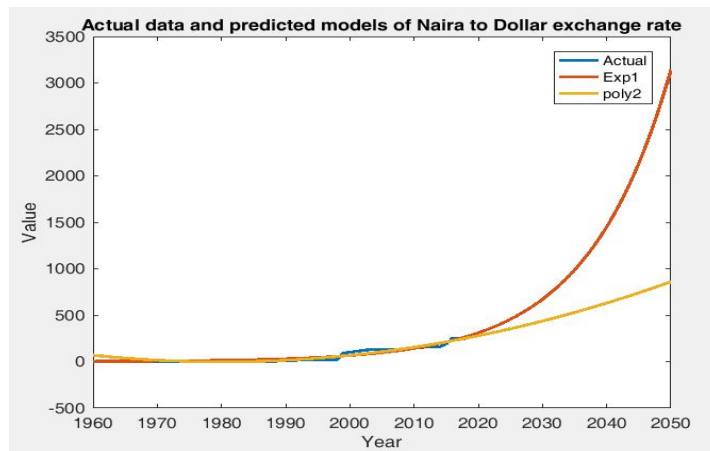


Fig 3: Actual versus predicted model of Naira to Dollar Exchange Rate (Accurate version)

This is further confirmed by fig. 4 where the exponential model exhibits an outrageous behaviour for any specific value of naira between the year 2020 and 2050. The exponential model finally predicted an exchange rate of ₦3000 to 1 dollar in 2050, whereas the polynomial model predicted that by 2050 the value of a dollar will be ₦800. Hence, exponential model will not be a good predictor of the exchange rate. Unlike the exponential model, the polynomial model is relatively stable and the value of naira to dollar in 2050 was predicted as ₦800. This is very close to what is available in literature.

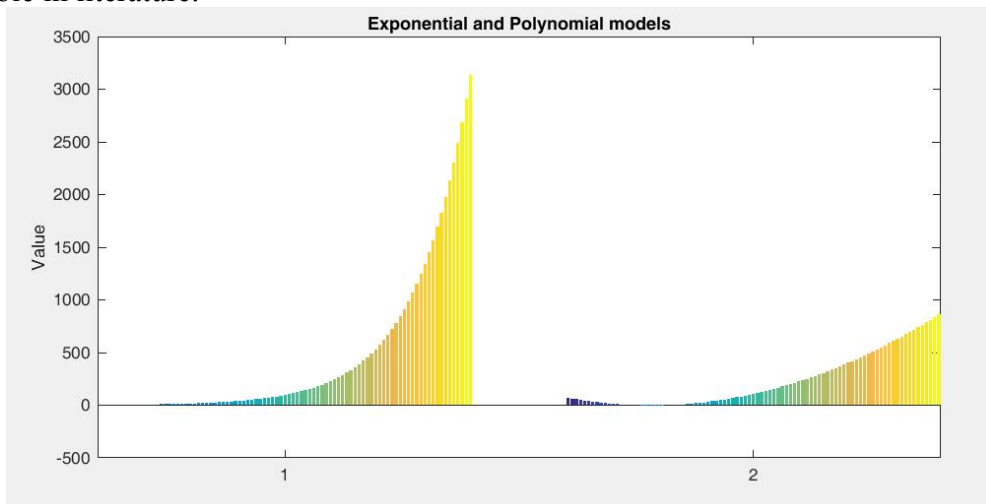


Fig 4: Behaviour of Exponential and Polynomial model

Though available research works have not predicted the exchange rate of naira to dollar up to the year 2050, but some of the closest research [12] and, [6] predicted the value of a dollar to be ₦300.46 and ₦304.32 respectively in the year 2020; which are almost the same with ₦300.50 naira obtained from our polynomial model. Again, the percentage errors obtained with our model table (Table 2) are very low and far better than those obtained in the existing models,

Table 1: Comparison of the Performance of Polynomial and Exponential Models

Year	Exchange Rate (₦)	
	Poly	Expo
1960	0.71	0.71
1970	0.71	0.71
1980	0.55	0.55
1990	8.04	8.04
2000	101.7	101.7
2010	150.3	150.3
2020	300.0	360.0
2030	400.0	500.5
2040	520.0	1000
2050	800.0	3000

Table 2: Analysis of the performance of Polynomial Model

Year	Exchange rate (Actual)	Exchange rate (Predicted)	Error	Percentage Error
1960	0.71	0.70	0.01	0.014
1970	0.71	0.69	0.00	0.028
1980	0.55	0.54	-0.01	-0.018
1990	8.04	8.02	-0.02	-0.002
2000	101.7	101.8	0.2	0.002
2010	150.3	150.4	0.1	0.007
2020	-	300.0	-	
2030	-	400.0	-	
2040	-	520.0	-	
2050	-	800.0	-	

5. Conclusion

In this research work, for the first time, we were able to study the performance of polynomial and exponential model in the prediction of naira to dollar exchange rate. The research confirmed that polynomial model is a better predictor. Based on this research, it was concluded that the value of naira will continue to depreciate unless the government of Nigeria take some urgent steps to revamp the economy of the country. All things being equal, it was predicted that by the year 2050, a dollar will be equivalent ₦800.

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