International Journal of Engineering, Science and Mathematics
Vol. 9 Issue 10, October 2020,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

Modeling Sudan's Inflation Rate using Multilayer feed forward Neural Network with Back Propagation Algorithm

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Abstract:

This paper aims to modeling and forecasting inflation rate in the Sudan using multilayer feed forward Neural Network with Back Propagation Algorithm. Yearly time–series data representing Inflation Rate (INF) Gross Domestic Product (GDP) , Exchange Rate (EXR), Demand for Money (M_2) for the Sudan covered the period from 1970 to 2014 are used in the analysis of this paper. Multilayer feed forward Neural Network with Back Propagation Algorithm was applied to the data. The empirical findings revealed that the training, validation and test curves are very similar. The best validation performance with mean squared error (MSE) 0.92.422 was found at epoch 4. The comparison between the actual inflation rate and the predicted showed that they are very close to each other which clearly reflected the efficiently of the model. This finding suggests that the ANN models create a significant power to modeling and forecasting the Sudan's inflation rate.

Keywords: Artificial Neural Networks, Back - Propagation, Forecasting, inflation, Sudan

1. Introduction:

Artificial Neural Network (ANN) is defined as computational tools for examining data and developing models that help to identify interesting patterns or structures in the data [1]. ANNs have verified to be one of the best forecasting models in many fields comprising economics and finance. In recent years ANNs have become extremely popular for prediction and forecasting in a number of areas, for instance economics, financial, business and engineering domains. Although the concept of artificial neurons was first introduced in 1943[2], research into applications of ANNs has blossomed since the introduction of the back propagation training algorithm for feed forward ANNs in 1986. ANNs may thus be considered a fairly new tool in the field of prediction and forecasting [3-6].

Inflation is a persistent increase in the general price level of goods and services in an economy over a period of time (Barro, 1997). Inflation can be defined as a continuous rise in the general price level or, alternatively, a continuous fall in the value of money. Inflation is usually reported as the percentage change in the price level, over the last 12 months. There are three major types of inflation:

Demands pull inflation: inflation from high demand for goods and low unemployment.

Costs push inflation: inflation caused by sudden decrease in the supply of goods, which would increase goods prices. Producers for these goods will increase the costs could then pass this on to consumers in the form of increased prices.

Anticipated: Prices rise because people expect them to rise. The major effects of inflation are: Creditors Lose: Net creditors are individuals or businesses that have more savings than debt. A net creditor receives interest and, therefore, receives a reduced real interest rate. Debtors Gain: Net debtors are individuals or businesses that have more debt than savings. A net debt or pays interest and, therefore, pays a lower real interest rate when there is unanticipated inflation**.** Inflation in general means an increasing of all prices in a given economy. It is present in the economy or any country when there is excess of money supply compared to the quantity of goods and services, if Inflation is high this would be considered as a serious illness of macroeconomics. Exchange rate refers to the number of units of one nation's currency that equals one unit of another currency (Tucker, 2006: 427). In Sudan, the inflation rate measures a broad rise or fall in prices that consumers pay for a standard basket of goods. The following paragraph demonstrate the fluctuation (increasing or decreasing by quarter) of inflation rate in the Sudan during the period 2000 -2017. The inflation rate Decreased from 13.4% by the end of December 2009 to 9.2% by the end of September 2010. The inflation rate Increased from 13.4% by the end of December 2009 to 13.0% by the end of June 2010. The inflation rate decreased from 17.1% by the end of March 2011 to 15.0% by the end of June 2011.The inflation rate increased from 37.2% by the end of June 2012 to 41.6% by the end of September 2012. The inflation rate decreased from 15.0% by the end of June 2011 to 20.7% by the end of September 2011. The inflation rate decreased from 20.7% by the end of September 2011 to 18.9% by the end of December 2011. The inflation rate increased from 22.4% by the end of March 2012 to 37.2% by the end of June 2012. The inflation rate increased from 44.4% by the end of December 2012 to 47.9% by the end of March 2013. The inflation rate increased from 27.1% by the end of June 2013 to 29.4% by the end of September 2013. The inflation rate increased from 29.4% by the end of September 2013 to 41.9% by the end of December 2013. The inflation rate decreased from 45.3% by the end of June 2014 to 39.2% by the end of September 2014. The inflation rate decreased from 39.2% by the end of September 2014 to 25.7% by the end of December 2014.The inflation rate decreased from 25.7% by the end of December 2014 to 23.2% by the end of March 2015The inflation rate decreased from 23.2% by the end of March 2015 to 18.3% by the end of June 2015. The inflation rate decreased from 18.3% by the end of June 2015 to 13.6% by the end of September 2015. The inflation rate decreased from 13.6% by the end of September 2015 to 12.6% by the end of December 2015. Inflation rate goes-down from 12.6% by the end of December 2015 to 11.7% by the end of March 2016.Inflation rate increased from 11.7% by the end of March 2016 to 14.3% by the end of June 2016. Inflation rate increased from 14.3% by the end of June 2016 to 18.3% by the end of September 2016. Inflation rate increased from 18.3% by the end of September 2016 to 30.5% by the end of December 2016Inflation rate increased from 30.5% by the end of December 2016 to 34.7% by the end of march 2017. Inflation rate decreased from 34.7% by the end of March 2017 to 32.6% by the end of June 2017. Inflation rate increased from 32.6% by the end of June 2017 to 35.1% by the end of September 2017. Inflation rate decreased from 35.1% by the end of September 2017 to 25.2% by the end of

December 2017. Monthly readings of inflation rate data in the Sudan covered the period from January 2008 – July 2015 are used in the analysis of this paper. The data are obtained from Central Bureau of Statistics as well as Central Bank of Sudan.

Figure (1) sequence chart of yearly readings of inflation rate in the Sudan for the period 1970 –2014.

Figure (1) represents the sequence chart of monthly readings of inflation rate in the Sudan for the period from 1970 – 2014. It can be shown that inflation rate in the Sudan fluctuate shows slightly increase till the mid of 2014 and then it sharply decreases till the beginning of 2016 and became a satiable till the end of study period.

2. Literature Review:

Nemours forecasting models were applied to modeling and forecasting inflation rate data. Among these Multi-layer feed-forward neural networks, this section shows the literature review of forecasting inflation rate using neural network models around the world, most papers confirmed that neural network models provide accurate predictions rather than other time series forecasting models.

Ahmed M. K. Arabi (2014) used two empirical approaches to forecasting inflation in Sudan. The first is structural model (single equation model) derived from economic theory and the second is a modern multivariate time-series Vector Autoregressive VAR augmented with Error Correction Model ECM. He used annually data of the consumer price index, money supply growth, exchange rate changes, imported inflation and real gross domestic product for period 1970-2008. his results showed that the VAR model exhibited greater predictive accuracy when compared to the single equation model and impulse response functions showed that expansionary monetary policy has an unambiguous expansionary effect on prices. Exchange rate stabilization was found to be the most effective means of short term stabilization [7].

Emi Nakamora (2005) evaluated the usefulness of neural networks for inflation rate forecasting using U.S. data, quarterly data covered the period from 1978 t0 2002 are used in the analysis, the empirical results concluded that, ANN models appear to play a significant role in the success of the neural network models [3].

Adnan.H. & Muhammed. N (2009) compared the performance of univariate time series forecasting models such as AR (1), ARMA and Artificial Neural Networks methods in forecasting inflation in Pakistan, various monthly macroeconomic variables such as inflation, GDP and currency in circulation data covered the period from July2003 to June2007 were used in the analysis. Based on the models selection criteria, it is found that the RMSE based on artificial Neural Networks is much less than RMSE based on AR (1) and ARIMA models, this result confirmed that forecast based on ANN are more precise.

Yousif. M, et al (2015) compared a traditional time series models such as AR (12), VAR(14) and ANN models in forecasting inflation in Ghana. Monthly data between the period January 1991 to December 2010 are used in the analysis, the traditional time series models compared with the ANN models, the empirical results confirmed that based on the RMSFE an ANN model are more accurate in forecasting inflation rate in Ghana.

Gour et al (2016) analyzed a historical monthly inflation data in India for the period January 2000 to December 2012, and constructed an inflation model based on feed forward back propagation neural network, accuracy of model was proved to be satisfactory when compared with the forecasting of some well-known agencies.

3. Multi-layer feed-forward (MLF) neural networks:

Multi-layer feed-forward neural networks, trained with a back-propagation learning algorithm, are the most popular neural networks. [16]. A Multi-layer feed-forward neural network consists of neurons that are ordered into layers. The first layer is called the input layer, the last layer is called the output layer, and the layers between are hidden layers. For the formal description of the neurons we can use the so-called mapping functionΓ, that a signs for each neuron i a subset $\Gamma(i) \subseteq \nu$ which consists of all ancestors of the given neuron. A subset $\Gamma^{-1}(i) \subseteq V$ than consists of all predecessors of the given neuron i. Each neuron in a particular layer is connected with all neurons in the next layer [19]. The connection between the i^{th} and j^{th} neurons is characterized by the weight coefficient ω_{ij} and the threshold coefficient of the i^{th} neuron is characterized by the threshold coefficient ϑ_i . the output activity of the i^{th} neuron x_i is calculated by equation (3.1) and (3.2) [16].

$$x_i = f(\xi_i) \qquad (3.1)$$

$$\xi_i = \vartheta_i + \sum_{j \in \Gamma^{-1}(i)} \omega_{ij} x_j \qquad (3.2)$$

Where ξ_i is the potential of i^{th} neuron and function, $f(\xi_i)$ is the so called transfer. The threshold coefficient can be understood as a weight coefficient of the connection with formally added neuron j, where $x_j = 1$(so called bias). For the transfer function it holds that:

$$f(\xi_i) = \frac{1}{1 + exp(-\xi)} \qquad (3.3)$$

In supervised adaptation process, the threshold coefficient ϑ_i and weight coefficient ω_{ij} are varied to minimize the sum of the squared differences between the computed and required output values. This is achieved by minimization of the objective function E [17] in equation (2.4) as

$$E = \sum_0 \frac{1}{2}(x_0 - \widehat{x_0}) \qquad (3.4)$$

Where x_0 and $\widehat{x_0}$ are vector composed of the composed of the computed and required activities of the output neurons and summation runs over all output neurons 0. In back propagation algorithm generally gradient descent minimization is used. Adjustments of the weight and the threshold coefficients are achieved as:

$$\omega_{ij}{}^{k+1} = \omega_{ij}{}^{k} - \lambda\left(\frac{\delta E}{\delta \omega_{ij}}\right)^{(k)}, \qquad (3.5)$$

$$\vartheta_{ij}{}^{(k+1)} = \vartheta_{ij}{}^{(k)} - \lambda\left(\frac{\delta E}{\delta \vartheta_{ij}}\right)^{(k)} \qquad (3.6)$$

Where λ is the learning rate ($\lambda > 0$). For more details for calculation $\frac{\delta E}{\delta \omega_{ij}}$ and $\frac{\delta E}{\delta \vartheta_{ij}}$ see [18].

Based on the above approach the derivatives of the objective function for the output layer and then for hidden layers can recurrently calculated. This algorithm is called the back-propagation, because the output error from the output layer through the hidden layers to the input layer [17].

4. Data and MODEL Specification:

Inflation measures the change in overall level of prices in an economy. Broad measures of inflation adopted are based on Gross Domestic Product (GDP) deflator, exchange rate, and demand for money (M_2). The data collected from Central Bank of Sudan (CBS) [7-12].

Historical annual data of four factors during the period from 1970 to 2014 would generate a vector of size [3× 44] with total of 44 samples. As these 3 factors would function as inputs of the proposed ANN, this vector is treated as input vector. The model is expected to predict annual inflation rate of the next years based on the input data provided for current year. Another vector called target vector of size [1× 44] is prepared containing the annual inflation rate of the corresponding next year's [18].

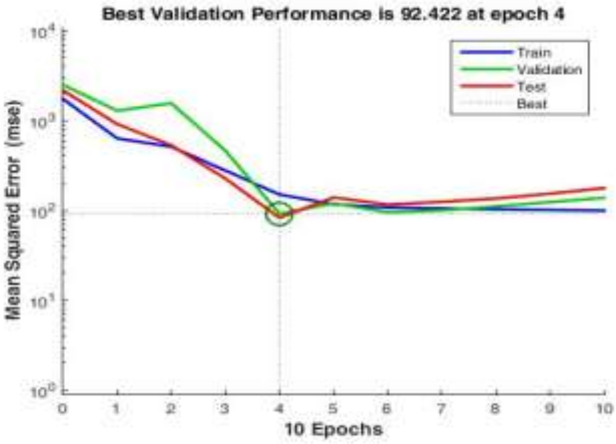
Neural network training can be made more efficient if certain preprocessing steps are performing the input and output data. MATLAB software was used to design and training the network, the most common functions used for input and output data processing are map-minmax and removecon- stantrow. To train multilayer networks the data set is divided into three subsets. The first one is the training set, and it used for computing the gradient and updating the network weight and biases. The second subset is validation set, it used for validation and the third, test set is used for checking test errors in the network.

5. Training, Testing and Validating the Network:

After preparing the data set, feed forward network is created and configured with the input layer having 10 input nodes, two hidden layers and the output layer with one neuron. The network is trained with the Levenberg – Marquardt algorithm proposed by More and Jorge [17]. Sigmoid function tansig is used in hidden layer and a linear function purelin is used for the output layer.

Figure (5.1) bellow illustrates the best validation performance of the inflation rate in the Sudan using macroeconomic data during the period 1970 to 2014.

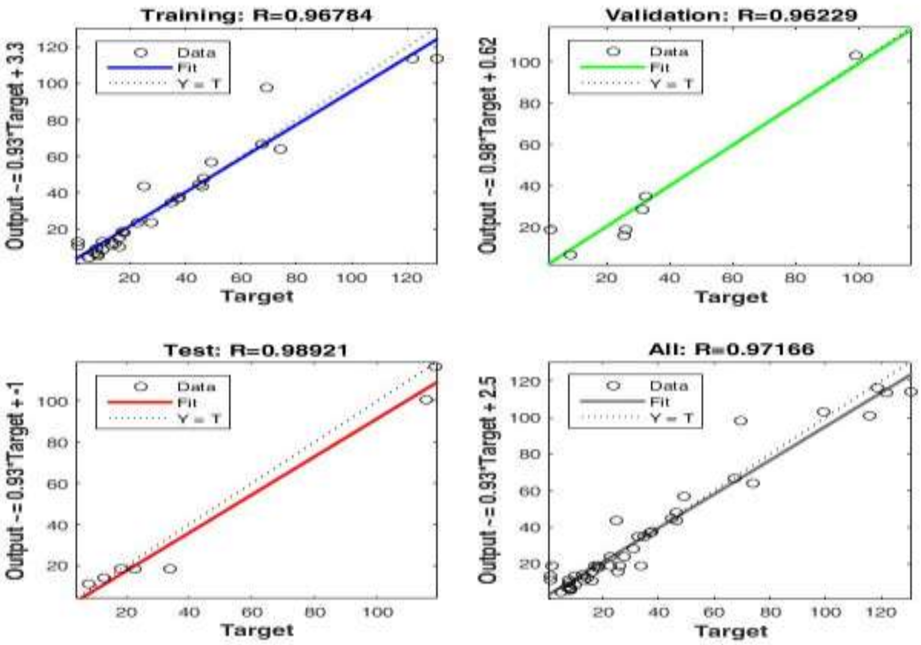
Fig (5.1) training performance of the inflation rate in the Sudan



Training performance of the proposed model is shown in fig (5.1). The training, validation and test curves are very similar. The best validation performance with mean squared error (MSE) 0.92 is found at epoch 4.

Figure (5.2) bellow illustrates regression performance of the inflation rate in the Sudan using macroeconomic data during the period 1970 to 2014.

Fig (5.2) training of the inflation rate in the Sudan regression model



Furthermore, in validation the network involves generating the regression plot shows the relationship between outputs of the network and the targets. If the training is perfect, the network outputs and the targets would be exactly equal however, the relationship is rarely perfect in practice [18-19]. The regression plot is shown in Fig (5.2). The three axes represent the training, validation and testing data. The dashed line in each axis represents the optimum results. The solid line represents the best fit linear regression line between outputs and targets. The R value is an indication of the relationship between the outputs and targets. If R = 1, this indicates that there is an exact linear relation and if R close to zero, then there is no linear relationship between outputs and outputs and targets. The algorithm is terminated to the early stopping procedure

6. Results analysis:

This section illustrate the empirical results of the application of a feed forward artificial neural network model with back propagation algorithm to forecasts annual inflation rate in Sudan, table (6.1) bellow demonstrates the actual inflation rate and prediction inflation rate for the years 2012 to 2014.

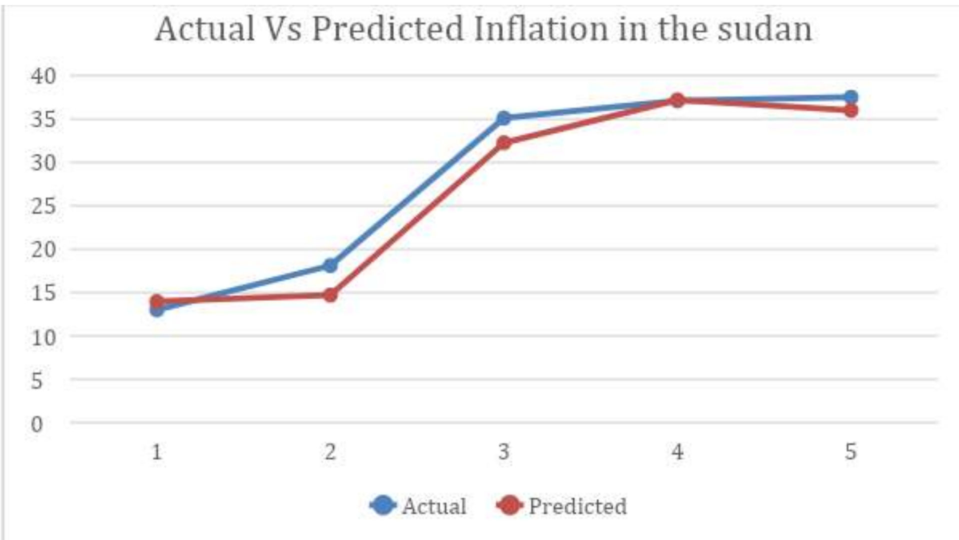
Table (6.1) Actual vs predicted inflation rate in the Sudan from the period 2012 to 2014.

inflation	Actual	Predicted
2012	13	13.946
2013	18.10	14.696
2014	35.10	32.258
2015	35.10	37.201
2014	37.50	36.005

Table (6.1) shows the details of actual inflation rate and prediction inflation rate for the years 2012 to 2014. it can be seen that the actual inflation rate and the predicted are very close to each other which clearly establish the and efficiently of the ANN model.

Figure (6.1) bellow shows the sequence charts of actual inflation rate versus the predicted inflation rate in the Sudan during the periods 2012 -2014.

Fig (6.1) Actual vs predicted inflation of the Sudan from the period 2012 to 2014.



From figure (6.1) it can be shown that the sequence charts of actual inflation rate versus the predicted inflation rate in the Sudan during the periods 2012 -2014 are very close to each other which clearly establish the and efficiently of the ANN model.

7. Conclusion:

This paper used a feed forward ANN method with back propagation algorithm in order to model and forecast annual inflation rate in the Sudan. Yearly time–series data representing Inflation Rate (INF) Gross Domestic Product (GDP) , Exchange Rate (EXR), Demand for Money (M_2) for the Sudan covered the period from 1970 to 2014 are used in the analysis of this paper. Multilayer feed forward Neural Network with Back Propagation Algorithm was applied to the data. The empirical findings revealed that the training, validation and test curves are very similar. The best validation performance with mean squared error (MSE) 0.92.422 was found at epoch 4. The actual inflation rate and the predicted are very close to each other which clearly reflected the efficiently of the model. This finding suggests that the ANN models create a significant power to modeling and forecasting the Sudan's inflation rate.

Declaration of competing interest

The authors declare that they have no known competing financial
Interests or personal relationships that could have appeared to influence the work reported in this paper

8. REFERENCES

1- K. A. Smith, Neural Networks in Business: Techniques and Applications. Idea Group Publishing, 2002.
2- Ke-Lin Du& M. N. S. Swamy, Neural Networks and Statistical Learning. Springer-Verlag London 2014.
3- E. Nakamura. Inflation forecasting using a neural network, Economics Letters 86 (2005) 373–378.
4- S. M. Cameron, Neural Network Versus Econometric Models in Forecasting Inflation, Journal of Forecasting (2000) 19, 201- 217.
5- Y.M. Hadrat1; E. Isaac K2 & E. Eric, Inflation Forecasting in Ghana-Artificial Neural Network Model Approach, International Journal of Economics &Management Sciences (2015) 4-8.
6- B. Onimode; Alhassan& S. Adepoju, Comparative Study of Inflation Rates Forecasting Using Feed-Forward Artificial Neural Networks and Auto Regressive (AR) Models, International Journal of Computer Science Issues, Volume 12, Issue 2, March (2015)260-265.

7- Ahmed M. K. Arabi (2014) Modeling and Forecasting Inflation in Sudan using multivariate time series model (VAR), University of BakhtAlruda Scientific Journal Issue No. 10.

8- Kenji M. & Abdul Naseer (2009) "Forecasting Inflation in Sudan" IMF – working paper, WP/09/132.

9- Badreldin M. A. Abdulrahman (2014) Inflation and Economic Performance in Sudan: An Analysis Study Researchjournali's Journal of Economics Vol. 2.

10- Kenji Moriyama (2008) "Investigating Inflation Dynamics in Sudan" IMF – working paper, WP/08/189.

11- Abdel-Rahman, A. M. M. (1995). Determinants of Inflation and its Instability: A Case Study of a Less Developed Economy. Estratto Da EconomiaInternationale, 11(4), Geneva.

12- M. Yol, Determinants of Inflation in Sudan: An Empirical Analysis, Policies, Research and Statistics Department, The Central Bank of Sudan (2010).

13- Kenji Moriyama and Abdul Naseer, Forecasting Inflation in Sudan, International Monetary Fund (2009).

14- K, C. M., and White, H. Artificial Neural Networks: An Econometric Perspective, Econometric Reviews (1994). 13, 1-91.

15- M. N., Saeed K. U. and Norman C. Econometrics versus ANN Models in Forecasting Inflation, Journal of Forecasting (2000)19, 201-217.

16- I. Aizenberg; C. Moraga, Multilayer feed forward neural network based on multi-valued neurons (MLMVN) and a back propagation learning algorithm, Soft Comput (2007) 11: 169–183.

17- M. Stinchconbe; H. White, Multilayer Feed Forward Networks Are Universal approximates Neural Networks, (1989) Vol. 2, 359-366.

18- G. Sundar, R. Bhattacharyya and S. Sarkar, Artificial Neural Network Based Model for forecasting of inflation in India, Fuzzy Information and Engineering. (2016) 8:87 -100.

19- D. Svozil. V, Kvasnicka. J. Pospichal, Introduction to Mult-layers Feed-forward network, chemometrics and intelligent Laboratory Systems 39(1) (1997) 43- 62.

20- Ibnouf, Abdel and Mohamed, Issam A.W., Impacts of Monetary Policies on Inflation Rates in Sudan (1970-2014), (2015), available at SSRN: https://ssrn.com/abstract=2579755.

21- Kabbashi M. Suliman (2012), The Determinants of Inflation in Sudan, AERC Research Paper 243 African Economic Research Consortium, Nairobi.

22- Badreldin M. A. Abdulrahman(2014), Inflation And Economic Performance In Sudan: An Analysis Study, research journals journal of economics, vol. 2, No 3

23- Jihan H. H &Kabashi H Suliman (2014), inflation Modeling for the sudan 1970 -2002, M.sc. Khartoum university, faculty of economics & social sciences.

24- Ibrahim A. Onour (2014), Modeling Inflation Dynamics in Sudan,Arab Center for Research and Policy Studies.

25- Dr. Mustafa Mohamed Abdalla (2010), Inflation Determinants in Sudan (1970-2009), The Central Bank of Sudan publications.

26- MarialAwouYol (2010), Determinants of Inflation in Sudan: An Empirical Analysis, The Central Bank of Sudan publications.