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Predicting the Factors Influencing Inflation in Iraq From (2016 – 2026)

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ABSTRACT

Inflation is one of the most significant contemporary economic issues, which has preoccupied economists for past decades. It is defined as a continuous increase in the general price level over more than a year due to economic reasons, which affects purchasing power—meaning that rising prices lead to a reduction in the purchasing power of goods and services. Tackling inflation and maintaining price stability are primary objectives that governments aim to achieve.

In this study, a simple regression model and a neural network were applied to forecast the inflation rate. The findings indicate an increase in inflation rates as a result of money supply growth. A simple linear regression model was applied for forecasting and analyzing the data, as well as assessing the suitability of the model used. To improve the model's accuracy, a multilayer neural network with backpropagation and feedforward networks was applied. The suitability of the independent variables was explained through network training, relying on the coefficient of determination to interpret the results obtained. Data was collected from the Central Bank of Iraq for the years 2004–2016 and analyzed using SPSS statistical software and MatlabR 2019b statistical program was used in the application of neural networks .

1. Introduction

Studying inflation is one of the essential indicators for measuring the overall economic level. Therefore, it is crucial to examine the factors influencing inflation, one of which is the money supply. The research problem lies in studying the money supply and its impact on inflation.

Numerous studies have addressed inflation [9], examining various factors such as exchange rates, population size, household expenditures, and money supply. These studies employed econometric methods to analyze and estimate the economic factors affecting inflation.

In this research, a simple linear regression model has been applied to investigate the relationship between inflation and the money supply and evaluate the independent

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variable's suitability in influencing inflation. This is compared with neural networks by examining the coefficient of determination and forecasting the time series.

2. Concept of the Simple Linear Regression Model

The simple linear regression model is a statistical method used to measure the relationship between two variables: a dependent variable and an independent (or explanatory) variable. The choice of these variables is often based on economic theory.

$$y_i = b_0 + b_1 x_i + u_i \quad \dots (1)$$

There are several factors that affect the dependent variable, and the choice of the explanatory variable must be based on strong objective justifications. When calculating the coefficient of determination, it indicates that changes in X explain a high proportion of changes in Y. The model is called simple linear regression because the relationship between the two variables involves just one dependent variable and one independent variable. To visualize this relationship, it takes the form of a straight line, and the function can be estimated by plotting the scatter plot, where pairs of points (x_i , y_i)align along the straight line.

The relationship between the variables is determined by the coefficient b_1.

1- If it is negative, it indicates an inverse relationship, and the model is expressed as follows:

$$y_i = b_0 - b_1 x_i \quad \dots(2)$$

2- If it is positive, it indicates a direct relationship, and the model is expressed as follows:

$$y_i = b_0 + b_1 x_i \quad \dots(3)$$

3. Assumptions of ordinary least squares (OLS)

The following linear model:

$$Y_i = B_0 + B_1 X_1 + U_i \quad \dots(4)$$

The above model is divided into two parts:

1. **The First Part**: Represented by the equation B0 + B1X1, which reflects the variations in the explanatory variable.
2. **The Second Part**: Represented by the random error term Ui, which refers to the unobserved factors. This represents the deviation of the estimated value of the dependent variable from its true value and is known as the **disturbance term**. It disrupts the linear relationship between the dependent and independent variables.

The deviation between the actual and estimated values can be attributed to several factors, including:

1- **Omission of some variables from the studied function**: This means excluding some variables that may influence the dependent variable, leading to ignoring potentially important effects.

2- **Random behavior of human beings**: This refers to the fact that human behavior can be random or unpredictable, which affects the final outcome of the model.

3- **Incomplete formulation of the mathematical model**: This occurs when the mathematical model is incomplete or lacks some of the influencing factors that should be included for accurate interpretation of relationships.

4- **Aggregation errors**: These occur when data is not collected or organized correctly, leading to inaccurate measurements or calculations.

5- **Measurement errors**

These four errors lead to an incorrect form of the equation. However, the measurement error for the observation itself must take into account the assumptions related to the properties of the random error Ui in the studied linear relationship.

Assumption 1:

The random variable is real, meaning that each value depends on chance and can be positive, negative, or equal to zero (Ui).

Assumption 2:

Based on the first assumption: E(Yi) = B0 +B1X …(5)

Assumption 3:

Var (Ui) = E[Ui−E(Ui)] = σ_u …(6) This means that the variance of the values of Ui around its mean is constant over time for all values of the independent variable Xi.

Assumption 4:

(U_i) follows a normal distribution, meaning that the distribution of (U_i) around its mean, which is equal to zero, is symmetric for each value of the independent variable (X_i)

$$(U_i) \sim N\ (0, \sigma_u)$$

Assumption 5:

$$Cov(U_iU_j) = E((U_iU_j) = 0 \quad , \ i \neq j \ , i , j = 1,2, \dots , n \quad \dots(7)$$

This means that the covariance between Ui and Uj is equal to zero, or in other words, the random error in one period does not depend on its value in another period and is independent.

Assumption 6:

$$E(U_iX_i) = 0 \quad \dots(8)$$

This means that the values of (U_i) are uncorrelated with any of the independent variables (X_i) This assumption is verified in practice by ensuring that the values of the independent variable (X_i) remain constant across different samples. To illustrate this, consider consumer demand studies, where the dependent variable represents the various goods that the consumer spends money on, while the independent variable remains constant for each group of goods being studied.

Assumption 7:

The independent variables should be uncorrelated with each other. This is particularly important when the model involves more than one independent variable. There should be no multicollinearity between the independent variables, allowing the dependent random variable to be identified independently.

Assumption 8:

The relationship to estimate its parameters must be properly diagnosed.
As for the properties of the dependent variable, it should follow a normal distribution.

$$\hat{Y} = E(Y_1) = B_0 + B_1X_1 \quad \dots(9)$$

$$Var(Y_1) = E\ [(Y_1) - E(Y_1)\ ] = \sigma_u \quad \dots(10)$$

That mean $Y_1 \sim N\ (B_0 + B_1X_1\ , \sigma_u^2)$

4. Neural networks [6]

Neural networks are one of the artificial intelligence techniques that mimic the human brain. They have become more advanced and complex than traditional methods for analyzing relationships between variables.

4.1. Components of Neural Networks [4,2] Neural networks consist of several layers as follows:

- **Input Layer**: This is the first layer of neural networks, and it receives the independent variables. It contains a number of neurons or processing elements equal to the number of independent variables.
- **Hidden Layer**: This is the layer following the input layer, consisting of one or more layers. The main task of this layer is to classify and analyze the inputs by assigning relative weights.

- **Output Layer**: This is the final layer, containing a number of processing elements that display the results obtained from the previous layer, thus providing the final output.

- **Relative Weights**: These determine the relative strength or importance of each input, which defines the strength of the relationship between the elements and processing units. The relative weights can be adjusted through training and learning.

4.1. Processing Units (Neurons)[3,5]

The layers are connected through weights, which are considered the primary element. The transfer function outputs values within a specific range [0,1],[1,-1] and compares the sum with the threshold value. There are several types of transfer functions:

1- **Sigmoid Function**
   This exponential function transforms outputs into values within [0,1] or [−1,1] and is referred to as the sigmoid activation function. It is one of the most widely used functions.
2- **Step Function**
   This function sets the output value to either 0 or 1 and is known as the binary activation function.
3- **Linear Function**
   In this function, the output equals the weighted input of the processing unit.
4- **Sign Function**
   The output value of the processing unit equals 1 or −1. It is used in classification tasks and pattern recognition.
5- **Output Function**
   This function adjusts the result of the transfer function.

4.2. Types of Neural Networks Based on Layers [10]:

1- Single-Layer Neural Network

2- Multi-Layer Neural Network

4.3. Practical Side

4.3.1. Introduction:

Inflation impacts the economic level of individuals due to continuous price increases, which affect all goods and services. This, in turn, impacts consumers' purchasing power, leading to a decrease in the value of the local currency against major international currencies.

In this study, the effect of money supply on inflation was analyzed, aiming to predict inflation for the upcoming years. Data was collected from the Central Bank of Iraq for the period (2004–2016) and analyzed using the SPSS statistical software to determine the relationship between money supply and

inflation, as well as by using Matlab R 2015 b Neural networks were applied, using a Multi - layer Neural Network , A feed forward backpropagation network with a single output, one hidden layer, and a linear transfer function in the output layer was implemented.

4.3.2. Data Analysis:

The data represents the inflation rate yi against the money supply x1 for the years 2004–2016, as shown in Table 1 below:

Table (1): Shows the money supply and inflation rate for the years (2004 – 2016) .

y_i Inflation rate	Cash display x_1	Year
26.96	10148626	2004
36.95	11399125	2005
53.23	15460060	2006
30.83	21721167	2007
2.69	28189934	2008
2.69	51743489	2009
3.1	51743489	2010
6.5	62473929	2011
6.1	63735871	2012
2.4	73830964	2013
1.6	72692448	2014
1.7	65435425	2015
1.5	70733027	2016

To study the effect of money supply xi and its impact on inflation yi, based on the results obtained and outlined below:

Table (2): The Effect of Money Supply on Inflation

R	R Square	Adjusted R Square	Std.Error of the Estimate
.945	.894	.884	8488174.625

The coefficient of determination R^2= 0.894 explains that 89% of the variation in inflation rates is due to the money supply.

Table (3): Analysis of Variance Table

S.O.V	Sum of Squares	df	Mean Square	F	sig
Regression	6.658e+15	1	6.658e+15	92.404	.000
Residual	7.925e+14	11	7.205e+13		
Total	7.459e+15	12			

From the table above, the calculated F value (92.404) is greater than the tabulated value (4.49) with degrees of freedom (1, 11). This indicates a statistically significant effect of the money supply on inflation.

Table (4): Predicted Values for Inflation Rate

year	Estimated inflation
2017	9.905
2018	13.259
2019	16.612
2020	19.966
2021	23.319
2022	26.673
2023	30.026
2024	33.380
2025	36.733
2026	40.086

The results indicate an increase in the predicted inflation rates for the years (2017–2026).

4.4. Prediction using Neural Networks [8]

For prediction using neural networks, the data is divided into three sets:

1. **Training Set**: This set includes 10 observations, representing 70% of the data.
2. **Validation Set**: This set includes 2 observations, representing 15% of the data.
3. **Testing Set**: This set also includes 2 observations, representing 15% of the data. From these, the architecture of the network is determined, and the activation function is used in the output layer to obtain the best hidden neurons.

The results show that the **Mean Squared Error (**MSE) = 2.1475e+09, and R^2 = 0.900. The figure below illustrates the architecture of the neural network, where the network was trained to achieve the minimum MSE.

This value shows that the model explains 90% of the changes or variances in the output data based on the independent variables used in the model. Meanwhile, the remaining 10% of the variances are unexplained, possibly due to other factors not included in the model or due to noise in the data.

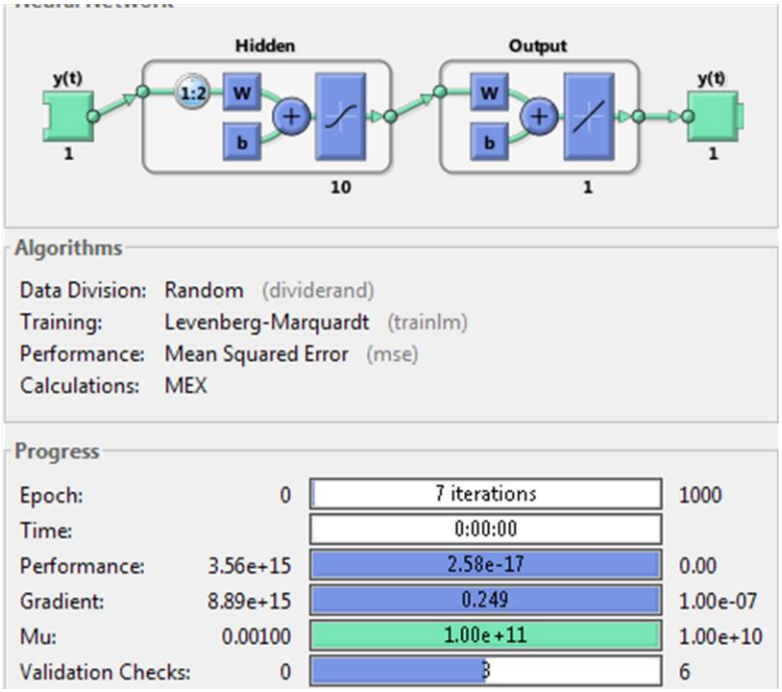

Figure (1). Neural Network Architecture for Money Supply

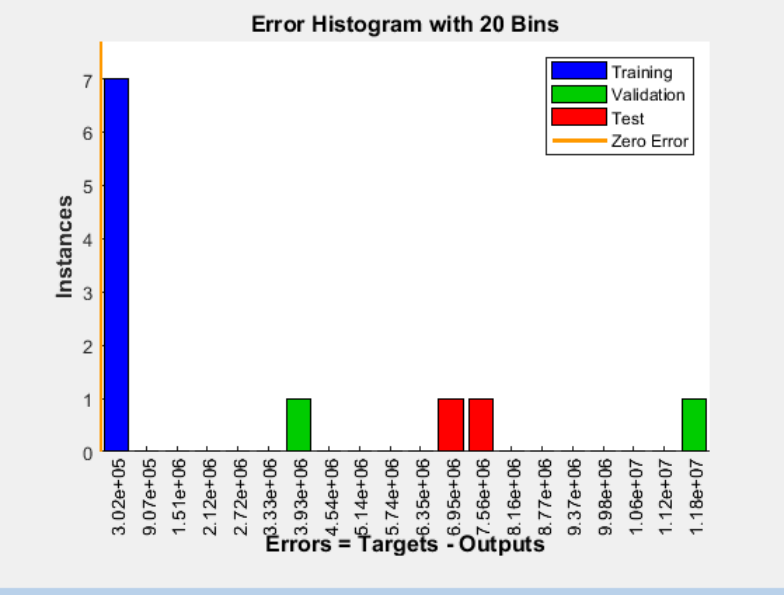

Figure (2). Decrease in network errors after training

5. Conclusions and Recommendations:

1. The results indicate that the money supply has an impact on increasing the inflation rate for the forecasted years. Therefore, we recommend strengthening the role of the Central Bank in implementing monetary and fiscal measures aimed at limiting market price deterioration and stabilizing the exchange rate.
2. The value of the coefficient of determination using neural networks is high, indicating the suitability of the independent variable in predicting the dependent variable

3- Coefficient of determination is a strong indicator that the model used is accurate and suitable for predicting the relationship between the input variables and the outputs.

4- The network was trained 7 times to achieve the minimizing the error errors and ensure the predictive quality of the model used, as explained by the coefficient of determination

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