Using Fuzzy-ARFIMA Models to Predict Births in Basra Governorate

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Abstract: Today's time series analysis is one of the most important statistical methods in forecasting, and it has been used in many economic, industrial, commercial and science fields, by representing time series characterized by long-term memory that helps predict future predictions and make appropriate and accurate decisions. In this research, we study prediction by relying on time series data for births in Basra Governorate. Using fuzzy-ARFIMA models and comparing them with each other using evaluation criteria (AIC & BIC) and (Adjust R-squared) for prediction, which are calculated using Eviews version (10), and Fuzzy-ARFIMA (12,0,104,12) was found. It is the best because it has the lowest values for (AIC & BIC) and the highest value for (Adjust R-squared), and also the highest forecasting efficiency because it has the lowest values for prediction accuracy scales (MAE & RMSE) and was chosen as the best model for predicting the future of monthly births in Basra.

1. Introduction
The importance of time series stems in future predictions for all areas that serve societies and humanity. Scientific developments no longer stop at presenting problems and studying their causes, but today they study the interactions between different sciences, analyze them and predict what will be the results of the studied phenomenon in the future. The interest in time series and its models is increasing day by day, and among the most important of these models is the autoregressive and differential fractional averages model which ARFIMA developed by (Granger and Joyeux, 1980) (Hosking, 1981)The Fuzzy Time Series model has a high capacity for solving various problems.
The number of births in Iraq in general, and in Basra in particular, is characterized by being inaccurate and the reason for this is the variation in the sources of the number of births in hospitals on the one hand, and the cases that come from outside, and this in turn makes the estimation of the number of births in an uncertain way, in addition to the cases that are not already registered from the above.
In our study, we will use Fuzzy-ARFIMA models to predict the number of births and to address the uncertainties about the number of births, thus predicting more accurately, And choose the best prediction model.
2. Previous studies
The current study was distinguished from previous studies in that it used the Fuzzy-ARFIMA model, and it proved its efficiency in predicting. Either the previous studies used the normal ARFIMA model only or the ARFIMA-ANN hybrid model. Among the most prominent of these research are:

2.1. A comparative study between the ARFIMA and ANN models in forecasting crude oil prices . (Al-Mabhouh, 2018). The study aimed to use the ARFIMA long-memory models and the ANN artificial neural network method to study crude oil price predictions. The importance of the research is due to the importance of oil prices in the economy of the exporting and importing countries. The study was conducted from 30/09/2013 to 09/03/2018 on crude oil price data in the state of Texas, USA. It concluded that the best model for representing the time series and predicting oil prices was ARFIMA. (1.0.375.1), followed by the MLP Artificial Neural Networks Model (2-25-1).

2.2. The optimal strategy for managing foggy stocks - Applied research in Baghdad Soft Drinks Company (Jassim, 2015). The study aimed to apply the fuzzy time series method to determine the economic quantities of production and demand for a can of Pepsi in the Baghdad Soft Drinks Company and to get rid of the fluctuations and oscillations associated with medicine.

2.3. Modeling the gold prices in Indonesia using the ARFIMA(Safitri et al., 2019). The importance of the study comes along because investing in gold is the best option to control financing, and it is easy to resell gold if there is a financial need at an unpredictable moment in time. The study aimed to predict the price of gold in Indonesia, and concluded that the efficiency of the ARFIMA method was ARFIMA (1.1.05716, 3).

2.4. Using ARFIMA-ANN Hybrid Models in Predicting Global Wheat Prices (Al-Taweel, 2019). The study aimed to use ARFIMA-ANN hybrid models in predicting global wheat prices. The importance of research is due to the global importance of wheat for all countries, and the study was conducted over ten years 1997 through 2017, and it came to the ideal model for time series representation and prediction Wheat price was the ARFIMA-ANN model, and the predictive values were consistent with the original values.

3. Definition of long memory
Time series is characterized by either the long-term process or the short-term; the long-term series is characterized by the continuity of its observations, and this makes the autocorrelation coefficients not exponentially decreasing towards zero when the displacement increases, and this is what the short-term time series means. The autocorrelation function behaves the hyperbolic behavior and decreases slowly at the polynomial rate. Upon this behavior the process is referred to as Long Memory Time Series (Tsay, 2005). There has been an increase in global interest in the study of time series known as Long Memory Dependence models, which have become an alternative to ARIMA models since they achieve stability by taking d fractions within the closed period [-0.5,0.5].

(Robinson, 2003) defines long-term time series based on the spectrum density function as follows:

\[ y_t \] is a stable process within the iteration field
\[ f(\lambda) \] - A spectrum density function that exhibits a long memory if it was \( f(0) = \infty \) which \( f(\lambda) \) have a fixed point at zero iteration
if \( f(0) = 0 \Rightarrow \lambda = 0 \) then \( y_t \) is a moderately, non-permanent, or negative memory process.
\( y_t \) is a short-memory method if \( f(0) = \sum_{k=-\infty}^{\infty} \gamma(k) \Rightarrow 0 < f(0) < \infty \)
4. Features of long memory models (ARFIMA)

The properties of ARFIMA (p, d, q) are defined by the different values of the fractional differentiation d has four cases (Tariq, 2014):

A. The string $y_t$ accepts inversion and is infinite: in the case of $(d > -1/2)$ the values of $\theta_q(L)$ fall outside the unit root.

B. The series $y_t$ is stable: in the case of $(d > -1/2)$ the values of $\phi_p(L)$ are outside the unit root.

C. The $y_t$ string accepts reflection with short and non-permanent memory: in the case of $(-1/2 < d < 0)$.

D. The $y_t$ series is stable with a long and continuous memory: in the case of $(0 < d < 1/2)$, here the values of the positive autocorrelation function slowly decrease towards zero in the form of a hyperbola, especially when the gap counter increases K. If the values of the fractional differentiation coefficient are within the closed interval $d \in [-0.5, 0.5]$ then ARFIMA $(0, d, 0)$ are models with long stable long memory accepting reflection. (John & Victoria, 2001)

5. Confirm and verify the long memory feature

Several graphs and statistical tests are used to confirm and verify the long memory characteristics, including:

5.1. Use of info graphics

Several graphs give a quick and clear indication of the existence of long memory. Among these fees:

- Autocorrelation function
- R / S diagram
- Higuchi method
- Variogram method
- Spectral density function

- R / S diagram

The R / S chart is an abbreviation for the Rescaled range, and also called the Hurst coefficient for testing the long memory of the time series (Hurst, 1951). It is calculated according to the following equations:

$$\ln[Q(t, k)] = \ln \left[ \frac{R(t, k)}{S(t, k)} \right] = \sum_{i=1}^{j} X_i$$

whereas:

$$R(t, k) = \max_{0 \leq i \leq k} \left[ \gamma_{t+i} - \gamma_t \frac{i}{k} \left( \gamma_{t+k} - \gamma_t \right) \right] - \min_{0 \leq i \leq k} \left[ \gamma_{t+i} - \gamma_t \frac{i}{k} \left( \gamma_{t+k} - \gamma_t \right) \right]$$

$$\bar{X}_{t,k} = \frac{\Sigma_{i=t+1}^{t+k} X_i}{k} S(t, k) = \sqrt{\frac{\Sigma_{i=t+1}^{t+k} (X_i - \bar{X}_{t,k})^2}{k}}$$

Let’s plot an R / S diagram. The two axes must be drawn $\ln[Q(t, k)]$, $\ln[k]$ whereas:

R: Range  S: Standard Deviation  k: Lags.

The straight line (y-axis) is estimated using the Ordinary Least Squares (OLS) method, which determines the relationship between $\ln[Q(t, k)]$, $\ln[k]$ (Beran, 1994).

5.2. The use of statistical tests

There are several statistical tests that are used to detect time series with long memory, including R / S analysis (Hurst, 1951), and Lo analysis (Lo-Andrews, 1991):
Lo analysis

It takes on the analysis of R/S its sensitivity about short-term correlations and thus its bias for short-term correlations, in addition to its inability to correctly represent the tests because it is a semi-parametric statistic and its distribution is unknown. Based on this, (Lo-Andrews, 1991) proposed a modified R/S statistic known by the following equations:

\[
\begin{align*}
Q_{mT} &= \frac{R}{S_T(q)} = \frac{1}{S_T(q)} \times \left[ \max_{1 \leq k \leq T} \sum_{j=1}^{k} (X_j - X_T) - \min_{1 \leq k \leq T} \sum_{j=1}^{k} (X_j - X_T) \right] \\
S_T^2(q) &= \frac{1}{T} \sum_{j=1}^{T} (X_j - X_n)^2 + 2 \sum_{j=1}^{q} \omega(q) \left[ \sum_{i=j}^{n} (X_j - X_T)(X_i-j - X_T) \right] \\
\omega_j(q) &= 1 - \frac{j}{q + 1}, \quad q < T
\end{align*}
\]

The modified R/S statistic is also subject to a known statistical distribution, which is calculated according to the following equation:

\[
v = \frac{Q_{mT}}{(T)^{1/2}}
\]

This is done by measuring the significance of the Horst factor through a comparison between the tabular value and the estimated (Lo; 1991)

It also allows testing the null hypothesis: $H_0$ the short-memory time series, Alternative hypothesis $H_1$ time series with long memory (Muhammad, 2012)

6. Fuzzy prediction for time series

Fuzzy logic or fuzzy prediction has recently been widely used in various scientific fields, especially all that are characterized by uncertainty, suspicion, or ambiguity.

The number of births may contribute to facilitating the development of the necessary future plans. The theory of fuzzy series is the origin of the term fuzzy logic, which is based on assigning degrees of affiliation to each of the elements of the actual groups Crisp within the fuzzy group. The main reason for the emergence of fuzzy logic is dealing with data that fall into the circle of doubt and uncertainty, so that traditional methods are no longer able to develop appropriate solutions

7. Fuzzy logic groups

Fuzzy logic has two types of groups:

7.1. Actual Crisp Set

\[\text{define( Klij & Yuna,1995) it as a group that includes elements with distinct qualities, which may or may not be specific, belong or not. These elements have two values, either (1) when belonging to the group, or (0) when not belonging to the group, and they were called the actual or traditional group to distinguish them in terms of definition from the fuzzy group.}\]

7.2. The Fuzzy Set

\[\text{describes (Zadeh,1965) it as a group that includes several types (classes) of elements that are characterized by a function of belonging that ranges between (0,1). Element (0) indicates that the element does not belong to the group, or the grades are between (0,1), so it is defined as follows (Muhammad,2007) :}\]

A. Affiliation score of 0.5 : the element belongs and does not belong to the fuzzy group of 0.5
B. Affiliation degree 0.7, 0.8, 0.9 : the element belongs to the fuzzy group with a high degree
C. The degree of affiliation 0.1, 0.2, 0.3 : the element belongs to the fuzzy group with a weak degree

8. Qualities of Fuzzy Logic:
Fuzzy logic has qualities that encourage its use in many scientific fields (Abdullah, 2012), including:

A. High flexibility.
B. Corresponds to any type or group of input or output data.
C. Ease of understanding and conclusion.
D. It is based on natural language without any complication.
E. The possibility of merging it with traditional technologies, without the need to delete or replace them.

9. Advantages of fuzzy group theory:
The fuzzy group theory is characterized by a set of characteristics, the most important of which are (Al-Tai, 2007; Darwish, 2012)

A. The possibility of its application in the absence of sufficient information and clearly, and this is in contrast to the usual group theory, which requires the availability of all the information for its elements.
B. The fuzzy group allows all objects to belong to it.
C. The belonging function that characterizes the fuzzy group reflects the arrangement of the elements within the global total.
D. Fuzzy logic integrates with any logic system.
E. Fuzzy logic reflects things as a set of variables.

10. Practical application

10.1. Data
In this study, the number of births in Basra Governorate will be predicted using the original data for years from January 2011 to December 2019 that were obtained from the Basra Health Department, using Fuzzy-ARFIMA models.

Table No. (1) of births in the Basra from (2011-2019)

| month | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  | 2017  | 2018  | 2019  |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1     | 9043  | 9823  | 9489  | 9894  | 9409  | 9059  | 9122  | 8859  | 8577  |
| 2     | 7645  | 8339  | 7775  | 8128  | 7538  | 7711  | 7265  | 6837  | 6366  |
| 3     | 7801  | 7860  | 8226  | 8866  | 7986  | 7426  | 7275  | 7104  | 7567  |
| 4     | 7032  | 7313  | 6918  | 7448  | 7328  | 7429  | 7455  | 7390  | 7205  |
| 5     | 6988  | 7168  | 7568  | 8517  | 7868  | 7966  | 7762  | 7382  | 7811  |
| 6     | 7813  | 8009  | 8079  | 8777  | 7833  | 7858  | 7853  | 7633  | 7842  |
| 7     | 8797  | 8834  | 9199  | 9147  | 9154  | 8996  | 9258  | 8581  | 7888  |
| 8     | 9179  | 8866  | 9361  | 9776  | 9334  | 9110  | 8881  | 8436  | 8003  |
| 9     | 9327  | 8866  | 8998  | 8942  | 8639  | 8302  | 8314  | 8465  | 8154  |
| 10    | 8954  | 8782  | 9012  | 9283  | 8962  | 8890  | 9408  | 8559  | 8274  |
| 11    | 8837  | 8535  | 8740  | 8934  | 8846  | 8761  | 8662  | 8501  | 8032  |
| 12    | 9211  | 8943  | 8986  | 9067  | 8738  | 8753  | 9266  | 8479  | 8426  |

*Table No. (1) shows the number of monthly deliveries for the years 2011-2019 that were obtained from the Basra Health Department / Planning Division

- For the purpose of obtaining data for a Fuzzy-ARFIMA, the following must be done:

10.2. Check long memory
The long memory is verified by calculating the Hurst parameter (H), and the time series has a long memory if the Hurst parameter is between (0.5 < H < 1).

Table (2) shows the values of the Hurst parameter.

Table No. (2) the values of the Horst parameter for the studied data series
is evident from the data in Table (2) that all the values of the Horst factor (H) were greater than 0.5, and this confirms the presence of the long memory characteristic of the series of births in Basra city. It turns out that the value of (H = 0.6441), which represents the slope of the straight line, which is a measure of the difference between short and long memory. In short time series the value of H is less than (0.5), and for time series with long memory, the value of H is greater than (0.5). As for time series with long memory, the value of H is greater than 0.5. This confirms that the data series births in the Basra city has a long memory, Figure (1).

![R/S Analysis](image)

**Figure No.(1)** diagram R/S the series births in the Basra city

- After making sure that the data has a long memory now, the data will be fogged using fuzzy analysis

### 10.3. Time series analysis using fuzzy prediction

The Chen Work FTS fog time-series model algorithm was used as a statistical method to address the uncertainty of births and predict them for the next period, the data may include (108) months Table (1)

- After processing the data with fuzziness, we will get fuzzy data, as shown in Table(3)

#### Table No. (3) the results of the fog processing process for all time series data Studied.

| years | months | Original births | Births after treatment for fuzzy |
|-------|--------|-----------------|---------------------------------|
| 2011  | 1      | 9043            | 8400                            |
|       | 2      | 7645            | 8200                            |
|       | 3      | 7801            | 8364                            |
|       | 4      | 7032            | 6950                            |
|       | 5      | 6988            | 7700                            |
|       | 6      | 7813            | 8364                            |
|       | 7      | 8797            | 8710                            |
|       | 8      | 9179            | 8675                            |
|       | 9      | 9327            | 8800                            |
|       | 10     | 8954            | 9400                            |
|       | 11     | 8837            | 8130                            |
|       | 12     | 9211            | 9217                            |
| 2012  | 1      | 9823            | 8250                            |
|       | 2      | 8339            | 8717                            |
|       | 3      | 7860            | 8364                            |
|       | 4      | 7313            | 7550                            |
| Year | Month | YYYMMDD | YYYMMDD |
|------|-------|----------|----------|
| 2013 | 1     | 9489     | 7983     |
|      | 2     | 7775     | 7850     |
|      | 3     | 8226     | 7500     |
|      | 4     | 6918     | 7700     |
|      | 5     | 7568     | 8350     |
|      | 6     | 8079     | 8650     |
|      | 7     | 9199     | 8675     |
|      | 8     | 9361     | 8800     |
|      | 9     | 8998     | 9400     |
|      | 10    | 9012     | 8400     |
|      | 11    | 8740     | 8710     |
|      | 12    | 8986     | 9400     |
| 2014 | 1     | 9894     | 8250     |
|      | 2     | 8128     | 8550     |
|      | 3     | 8866     | 8130     |
|      | 4     | 7448     | 8083     |
|      | 5     | 8517     | 8125     |
|      | 6     | 8777     | 8710     |
|      | 7     | 9147     | 8675     |
|      | 8     | 9776     | 8950     |
|      | 9     | 8942     | 9400     |
|      | 10    | 9283     | 9217     |
|      | 11    | 8934     | 9400     |
|      | 12    | 9067     | 8400     |
| 2015 | 1     | 9409     | 7983     |
|      | 2     | 7538     | 8350     |
|      | 3     | 7986     | 7600     |
|      | 4     | 7328     | 7550     |
|      | 5     | 7868     | 8364     |
|      | 6     | 7833     | 8364     |
|      | 7     | 9154     | 8675     |
|      | 8     | 9334     | 8800     |
|      | 9     | 8639     | 9100     |
|      | 10    | 8962     | 9400     |
|      | 11    | 8846     | 8130     |
|      | 12    | 8738     | 8710     |
| 2016 | 1     | 9059     | 8400     |
|      | 2     | 7711     | 7850     |
|      | 3     | 7426     | 8083     |
|      | 4     | 7429     | 8083     |
|      | 5     | 7966     | 7600     |
|      | 6     | 7858     | 8364     |
|      | 7     | 8996     | 9400     |
|      | 8     | 9110     | 8675     |
|      | 9     | 8302     | 8717     |
10  8890  8130
11  8761  8710
12  8753  8364

2017
1   9122  8675
2   7265  7650
3   7275  7650
4   7455  8083
5   7762  7850
6   7853  8364
7   9258  9217
8   8881  8130
9   8314  8717
10  9408  7983
11  8662  9100
12  9266  9217

2018
1   8859  8130
2   6837  7150
3   7104  7700
4   7390  7550
5   7382  7550
6   7633  8200
7   8581  8125
8   8436  8550
9   8465  8550
10  8559  8125
11  8501  8125
12  8479  8550

2019
1   8577  8125
2   6366  7550
3   7567  8350
4   7205  7650
5   7811  8364
6   7842  8364
7   7888  8364
8   8003  8650
9   8154  8550
10  8274  7500
11  8032  8650
12  8426  8550

* In Table No. (3) Some numbers have been rounded off to be whole numbers, as they represent births

- In order to predict the births, the fuzzy data will be worked on according to the ARFIMA model, by following the following steps:

10.4. Descriptive analysis of fuzzy data

Figure (1) shows some statistical measures that give a general idea of fuzzy data.
Figure No.(2). Some statistical measures of fuzzy data.

The data of Figure (2) show that the highest fuzzy value for births was (9400) births per month, while the lowest value for births per month was (6950). The numerical mean of births per month was (8361.918) births per month with a standard deviation of (537.393). The was greater than the arithmetic mean and reached (8364.286) births per month. This indicates the lack of moderation in the distribution of the data, as the curve tilts the data to the right, this is confirmed by the positive skewness coefficient (0.05), and the coefficient of kurtosis reached (2.763), which is a value smaller than (3). This indicates that the data distribution curve is oblate.

10.5. Stages of applying the Fuzzy-ARFIMA methodology

10.5.1. Dormancy test

Figure (3) shows the curve of the fuzzy monthly births in Basra city in terms of the arithmetic mean and the fuzzy variance.

Figure No.(3) Curve of fuzzy monthly births.

It is evident from Figure (3) that the time series of fuzzy births in the city of Basra is the subject of the study, and is static. This is confirmed by drawing the ACF function and the partial correlation function PACF Figure (4). It appears that the fuzzy data is decreasing in waves that simulate the sinusoidal function to zero, and this indicates that the chain is static and has a long memory.

Figure No.(4) The autocorrelation and partial autocorrelation functions of fuzzy data.
10.5.2. Definition and Assessment:

From Figure (3) it was shown that the ACF autocorrelation function decreases in waves simulating the sinusoidal function to zero, and to determine the three ranks of the Fuzzy-ARFIMA model (p, d, q), the partial autocorrelation function PACF is used, which shows us that the two periods, lag (1) and lag (12), were the largest significant (high top), and therefore may be the most representative of the data. To confirm this, the value of the fractional difference d at the periods lag (1) and lag (12) is calculated using Eviews version (10). Table (4) shows the values of the fractional difference and the candidate ARFIMA models for the fractional difference.

| Fractional Difference | ARFIMA Model | BIC   | AIC   | Adjusted R-squared | d   |
|-----------------------|--------------|-------|-------|--------------------|-----|
| 0.133                 | (1,d,0)      | 15.338 | 15.437 |                      | 0.367 |
| 0.134                 | (1,d,1)      | 15.354 | 15.478 |                      | 0.289 |
| 0.283                 | (1,d,12)     | 15.186 | 15.311 |                      | 0.568 |
| 0.313                 | (12,d,0)     | 15.137 | 15.237 |                      | 0.125 |
| 0.316                 | (12,d,1)     | 15.149 | 15.273 |                      | 0.037 |
| **0.363**             | **(12,d,12)**| **15.104** | **15.228** |                  | **0.104** |

It is noted from the data in Table (4) that:
- It excludes Fuzzy-ARFIMA (1, d, 12) because the fractional difference value was greater than the range [0.5, -0.5]
- It is evident from the remaining models that the best model is Fuzzy-ARFIMA (12,0.104,12), as it has the lowest BIC and AIC values and the highest Adjust R-squared value.

Based on the above, the model that can be used in forecasting is Fuzzy-ARFIMA (12,0.104,12), and estimates of the model parameters are as follows Table (5):

| p-value | standard error | estimation | parameter | Sample |
|---------|----------------|------------|-----------|--------|
| 0.000   | 0.088          | 0.866      | φ         | AR(12) |
| 0.002   | 0.16           | -0.51      | θ         | MA(12) |

10.5.3. Test of Fuzzy-ARFIMA parameters (12,0.104,12)

From Figure (5), we find that the congruence between the original and estimated data series curves was high, and this it gives an indication of the importance of the Fuzzy-ARFIMA (12,0.104,12) model in representing birth data in the city of Basra.

![Figure No.(5)Series of original and estimated data and the Residuals foggy of births in Basra of city](image-url)
And based on previous tests and examinations of residues resulting from a sample Fuzzy-ARFIMA (12,0.104,12) was relatively consistent with the theoretical assumptions on which the model relies, which increases the efficiency of this model in analyzing the data under study, and thus its use in prediction.

10.5.4. Forecasting the Fuzzy-ARFIMA (12,0.104,12) model

Table (6) shows the forecast by applying the Fuzzy-ARFIMA (12,0.104,12) model for the year 2019 from January to December and comparing it with the fuzzy data.

| Date     | Fuzzy values $y_t$ | Predicted values $\hat{y}_t$ | Residuals $e_t = y_t - \hat{y}_t$ |
|----------|-------------------|-------------------------------|---------------------------------|
| 01/2019  | 8125              | 8303.737                      | -178.737                        |
| 02/2019  | 7550              | 7743.164                      | -193.164                        |
| 03/2019  | 8350              | 7908.232                      | 441.768                         |
| 04/2019  | 7650              | 7918.274                      | -268.274                        |
| 05/2019  | 8364.285714       | 7884.706                      | 479.580                         |
| 06/2019  | 8364.285714       | 8309.808                      | 54.477                          |
| 07/2019  | 8364.285714       | 8546.527                      | -182.242                        |
| 08/2019  | 8650              | 8447.027                      | 202.973                         |
| 09/2019  | 8550              | 8591.385                      | -41.385                         |
| 10/2019  | 7500              | 8257.050                      | -757.050                        |
| 11/2019  | 8650              | 8450.155                      | 199.845                         |
| 12/2019  | 8550              | 8618.532                      | -68.532                         |

Table (7) shows the predictive accuracy indicators of Fuzzy-ARFIMA (12,0.104,12).

| Fuzzy-ARFIMA (12,0.104,12) | RMSE   | MAE   |
|----------------------------|--------|-------|
|                            | 324.45 | 255.67|

The researcher made a five-year prediction (2020-2024), and it was explained in the following table:

| year / Month | Fuzzy-ARFIMA(12,0.104,12) | year / Month | Fuzzy-ARFIMA(12,0.104,12) |
|--------------|---------------------------|--------------|---------------------------|
| 01/2020      | 8053.039                  | 07/2022      | 8420.025                  |
| 02/2020      | 7800.138                  | 08 / 2022    | 8352.167                  |
| 03/2020      | 7788.989                  | 09 / 2022    | 8574.760                  |
| 04/2020      | 7508.193                  | 10 / 2022    | 8297.145                  |
| 05/2020      | 7776.366                  | 11 / 2022    | 8320.996                  |
| 06/2020      | 8269.149                  | 12 / 2022    | 8624.063                  |
| 07/2020      | 8485.247                  | 01 / 2023    | 7965.402                  |
| 08/2020      | 8417.817                  | 02 / 2023    | 7707.131                  |
| 09/2020      | 8640.755                  | 03 / 2023    | 7693.550                  |
| 10/2020      | 8363.425                  | 04 / 2023    | 7411.281                  |
| 11/2020      | 8387.515                  | 05 / 2023    | 7678.449                  |
| 12/2020      | 8690.784                  | 06 / 2023    | 8170.496                  |
| 01/2021      | 8032.298                  | 07/2023      | 8386.032                  |
| 02/2021      | 7774.177                  | 08 / 2023    | 8318.155                  |
| 03/2021      | 7760.729                  | 09 / 2023    | 8540.731                  |
In order to study the prediction for a period of five years from 2020 to 2024, apply this via Eviews v.10. Figure (6) indicates the forecast curve based on the Fuzzy-ARFIMA model.

Table No. (9) shows indicators of prediction accuracy for Fuzzy-ARFIMA (12,0.104,12)

| Fuzzy-ARFIMA (12,0.104,12) | RMSE | MAE  |
|-----------------------------|------|------|
|                             | 324.45 | 255.67 |

11. Conclusions

The study aimed to build the best model to predict births in Basra city on a monthly basis, using the Fuzzy-ARFIMA model. After applying the model to the studied data series, the following results were obtained:

i. The data series for monthly deliveries in Basra were static.

ii. The data series for monthly births in Basra city was characterized by the long memory feature, as indicated by the graph of the self-correlation function and statistical tests.

iii. The results of estimating the fractional differences d according to the methods used were useful in stability the series based on the results of the ADF test where the p-value was smaller than the level of significance \( a = 0.05 \).

iv. It was found that Fuzzy-ARFIMA (12,0.104,12) was better model in predicting because it had lower values of prediction accuracy criteria.

v. Births forecast results indicate that the birth rate will continue with the same pattern of increase and decrease for months in the future.
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