American Journal of Social and Humanitarian Research

Vol. 6 Issue 6 | pp. 1360-1367 | ISSN: 2690-9626
Available online @ https://globalresearchnetwork.us/index.php/ajshr

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Article

Predicting The Exchange Rate of The US Dollar Against The Iraqi Dinar ID Using Time Analysis Techniques

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Abstract: This research aims to study Box-Jenkins models. ARIMA models, which rely on the degree of auto regression, the degree of integration, and the degree of moving averages to predict the exchange rate of the US dollar against the Iraqi dinar ID. The Box-Jenkins methodology was developed to construct a time series model, and then select the best model to predict future values of the US dollar exchange rate against the ID. Forecasting was conducted on a four-year time series, from 2022 to 2025. It was found that the best forecasting model is (2,1,4).

Keywords: Exchange Rate, Forecasting, Moving Averages, Auto Regression, Box-Jenkins

Citation: Hameed, Z. A. Predicting The Exchange Rate of The US Dollar Against The Iraqi Dinar ID Using Time Analysis Techniques. American Journal of Social and Humanitarian Research 2025, 6(6), 1360-1367.

Received: 30th May 2025
Revised: 7th Jun 2025
Accepted: 16th Jun 2025
Published: 23rd Jun 2025

1. Introduction

Forecasting in economics has gained significant study and attention due to the development of economic institutions. It has become a more effective and accurate tool for predicting future events, helping organizations better prepare for anticipated changes in various fields, including market fluctuations and product demand. Contemporary management must accurately forecast future sales due to the ambiguity of circumstances and their rapid changes [3]. This serves as a guide to charting the path they must take if they wish to advance in their field of activity or at least maintain their current position in their business environment. Economic forecasting is a topic of great importance, as it predicts economic variables, enabling decision-makers to formulate economic policies for the coming periods [1]. The researcher (Arhaif, 2009) aimed to predict the quantities of Iraqi cement production for the future period (2003-2013) using the best suitable Box-Jenkins models. The researcher concluded that using the Box-Jenkins method, the series was found to be unstable, and thus the first difference was taken in order to achieve stability. Also, from the behavior of the autocorrelation coefficients and partial correlation, it was concluded that it is possible to determine and choose the appropriate model to represent the series, where the appropriate model was (2, 1, 0) ARIMA. It was also found that the lower limits of the prediction may be negative, which indicates that in the case of an urgent need for this material, local production may not be sufficient, so the country resorts to filling the shortage through imports. The researcher (Abdul Amal, 2022) presented a study analyzing the current and future behavior of the time series of gross fixed capital formation in the Kingdom of Saudi Arabia. The study confirmed through stationarity tests that the time series under study was not stable in its level, but it stabilized after being put in the form of first differences. The study used the Box-Jenkins methodology in forecasting and analyzing time series, and it was concluded that the best model that fits the data of the gross fixed capital formation series is the ARIMA (2,1,4) model. This model was used for future forecasting for the years from 2020 to 2023 AD. The forecasting results at the level of the Kingdom of Saudi Arabia showed that the total expected gross fixed capital formation will range between approximately (19.6-29.4) billion riyals during the forecast period, and that the gross fixed capital formation in the Kingdom of Saudi Arabia is taking an upward trend during the forecast period (2020-2023). The study reached a number of recommendations, the most important of which is to benefit from the results of this study to predict the gross fixed capital formation for the coming years, and to conduct other predictive studies for some important economic indicators, such as the gross domestic product (GDP) and foreign direct investment. The researcher (Mohamed, 2023) presented a test of the effectiveness of applying the Box-Jenkins model in time series analysis in predicting the GDP variable and formulating a standard model through which the size and value of GDP in Sudan can be predicted. The problem of the study was represented by the question: To what extent can Box-Jenkins models be relied upon in analyzing the time series of the GDP variable in Sudan during the period 2010-2021 and forecasting it until the year 2030? The study used the modern quantitative approach to time series analysis and forecasting using the Box-Jenkins methodology, as it is the basic approach for this study. One of the most important results of the study is that the ARIMA model is the best, as it is characterized by a high ability to predict future GDP values. It became clear that the estimated values of GDP are somewhat close to the actual values and can be used to predict the variable in the future.

Given the great importance of forecasting, the following question can be raised: Can Box-Jenkins models be relied upon to forecast the ID exchange rate against the US dollar for the coming months (April 2025-November 2025)? To address this problem, the following sub-questions can be formulated:

1. What is the degree of integration that can be adopted in the ID exchange rate series against the US dollar ?
2. Are there seasonal components in the ID exchange rate series against the US dollar ?
3. What is the rank of auto regression and moving averages that yield the lowest value for the Akaike information criterion and, therefore, the best forecasting result ?

2. Materials and Methods

By The descriptive-analytical approach was adopted, a method widely used in the social and behavioral sciences. It is a method for describing and quantitatively depicting the phenomenon under study by collecting, classifying, analyzing, and accurately studying data related to the problem. This approach also contributes to providing data and analyzing phenomena and facts about the problem under study. To support this study, statistical methods were employed to clarify the study variables. The statistical program SPSS was used to facilitate calculations.

Study Hypotheses

1. Predict a specific strategy for future forecasts based on historical observations and analysis.
2. The degree of integration of the sales series is usually first-order (where the series stabilizes at first differences).

Research Objective

To illustrate how to forecast using the Box-Jankins methodology, and to conduct a statistical study to predict the future exchange rate of the ID against the US dollar.

Box-Jenkens Methodology (ARIMA) in Time Series

Time series analysis is an important process for quantitative forecasting methods because it relies on current and past data to provide a clear picture of the future of the phenomenon to be studied, its behavior, the influences that affect it, and also how it interacts. The methodology applied by George Box and Gwilyn Jenkens to time series in 1970 is called the Box-Jenkens methodology. This methodology provides solutions to many time series problems and also gives accurate predictions for the time series. ARIMA models are an organized method for building and analyzing models until we find the optimal model that is obtained with the minimum errors [Al-Satouri, Al-Hiti, 2010]. This methodology is divided into several stages, which are:

3. Results and Discussion

The first stage: Identification Phase

The most important stage in model development is the identification phase, which relies on the data series provided in the study. The first step in the identification phase is plotting the time series data to examine the presence of trends, seasonality, outliers, non-stationary variance, and other non-stationary phenomena.

In the second step, the sample autocorrelation function (SACF) and the partial autocorrelation function (SPACF) are calculated. If the series is stationary in the first step, the sample autocorrelation function (SACF) and the sample partial autocorrelation function (SPACF) in the second step are the same. In the third step, the model rank is determined using the autocorrelation functions (ACF) and partial autocorrelation functions (PACF). However, matching the autocorrelation coefficients and partial autocorrelation coefficients of the original series with the theoretical behavior does not lead to the final step of determining the model and its rank. We may encounter some difficulties in determining the model and its rank when these coefficients do not behave in the theoretical behavior. This leads to the emergence of more than one model to represent the time series, which prompts the researcher to select several models, and choose the appropriate model that matches his data. The table below shows the theoretical properties of the ACF and PACF functions for stationary series.

Table 1. Theoretical properties of the ACF & PACF functions for stable series.

The process	(ACF)	(PACF)
AR(p)	It fades exponentially	It dissipates after the p shift
MA(q)	It breaks after the shift q	It fades exponentially
ARMA(q,p)	It fades after the shift (q-p).	It fades after the (q-p) shift

The Second Stage 2: Parameter Estimations

This stage includes estimation, diagnostic validation (model verification), and model selection (Abdul Qader and Hassan, 2021).

A- Estimation

After the model is defined and its score is determined, its parameters are estimated. Several methods are used for estimation, the most important of which is the Maximum Likelihood Method. Other methods are added, including the Yule-Walker equations, the least squares method, and the nonlinear estimation method. (Hashy and Faiza Umm Al-Khair 2023)

B- Fitting Model Test

Autoregressive Models (AR): This type of model explains the dependent variable representing the phenomenon under study solely through its past, which represents its past behavior and is denoted by the symbol AR and written as follows: [Imad Al-Din and Ahlam Maqrani, 2015].

$$y_t = \emptyset_0 + \emptyset_1 y_{t-1} + \emptyset_2 y_{t-2} + \cdots + \emptyset_p y_{t-p} + \varepsilon_t$$

Where t represents the value of the variable in the current period t, ε represents the random error term in period t, y_(t-1),y_(t-2),y_(t-p) represent the values of the variable in the previous period, ∅_0 represents the constant, *∅_1…∅_p* represent the parameters of the model, and p represents the score of the model.

- Moving Average Models (MA): The values of the current variable in this method depend on the values of the previous and current random variables. This model is written as follows:

$$y_t = \emptyset_0 + \varepsilon_t + \emptyset_1 \varepsilon_{t-1} + \cdots + \emptyset_q \varepsilon_{t-q}$$

Where *∅_0,∅_1,∅_q* are the model parameters that can be positive or negative and $\varepsilon_t, \varepsilon_{t-1}, \varepsilon_{t-q}$are moving averages of the stochastic term values in period t and in previous periods, q represents the model score.

- Mixed ARMA Models: These models include the p-degree regression section and the q-degree moving average section, as shown below:

$$y_t = \emptyset_1 y_{t-1} + \emptyset_2 y_{t-2} + \cdots + \emptyset_p y_{t-p} + \delta + \varepsilon_t + \emptyset_1 \varepsilon_{t-1} + \emptyset_2 \varepsilon_{t-2} + \cdots + \emptyset_q \varepsilon_{t-q}$$

The properties of this model are that ARMA(*p,q*) is stable if AR(*p,q*) is stable, and ARMA(*p,q*) is invertible if AR(*p,q*) is invertible.

- Unstable ARMA(*p,q*) models: This model relies mainly on applying the first-order difference method to obtain its stability.

- Seasonal mixed models 〖SARIMA〗 (*p,d,q*): It is called the mixed model with seasonal component and can be expressed mathematically as follows:

$$\varphi_{Ls} = 1 - \varphi_1(L^s) - \varphi_2(L^{2s}) - \cdots - \varphi_p(L^{ps})$$
$$\theta_{Ls} = 1 - \theta_1(L^s) - \theta_2(L^{2s}) - \cdots - \theta_p(L^{ps})$$

$\nabla_S^D = (1 - L^s)^D$ Represents seasonal variations of degree $D$and$\nabla^d = (1 - L)^d$ Successive differences of degree d are used to establish the stationarity of y_t.

C- Model Checking

In this step, the estimated model is verified to ensure that it is the appropriate model, free of autocorrelation and moving average structures. This is done by examining the autocorrelation coefficients and partial autocorrelation coefficients of the residuals in the model, not the original series. If all autocorrelation coefficients for a number of gaps fall within a 95% confidence interval, then the autocorrelation between the random error terms is insignificant. In this case, this model is considered appropriate for estimation and prediction. If it is not, another model is sought.

There are some other criteria to check the model and ensure that it is the appropriate model, such as [Matroushi, 2011]:

1- Ljung-Box Q Statistic: It is used to test hypotheses.

$H_0: P_1 = P_2 = \cdots = P_k = 0$

$H_1: P_1 \neq P_2 \neq \cdots \neq P_k \neq 0$

where P_i represents the autocorrelation coefficients of the model residuals. It has the following formula:

$$LBQ = n(n+2) \sum_{k=1}^{m} [\frac{\hat{p}^2{}_k}{n} - k]$$

m represents the number of previous time lags included in the test, n is the number of observations used in the estimation, and the series is non-stationary when the calculated LBQ value is greater than x^2, the table value with m degrees of freedom, where the null hypothesis that all autocorrelation coefficients are equal to zero is rejected and vice versa.

2- Akaike Information Criteria: It is given by the following relationship:

$$\mathrm{AIC} = \mathrm{T} \ln\left(\sum e^2{}_i\right) + 2\mathrm{n}$$

3- Schwarz Bayesian Criterion: It has the following formula:

$$\mathrm{SBC} = \mathrm{T}\ln\left(\sum \mathrm{e^2}_{\mathrm{i}}\right) + \mathrm{n}\ln(\mathrm{T})$$

Where n is the number of parameters estimated in the model, T is the number of observations, e is the random error, the model that gives the lowest value of AIC and SBC is chosen.

A number of predictive accuracy tests are also used to show the extent to which the model is suitable for making predictions. These tests include: [Taylor, 2008]

1-: Mean-Square error (MSE) This test is calculated according to the following formula:

$$MSE = \sum_{t=1}^{T}(e_t)^2/T$$

T represents the number of observations, e represents the random error

2-: Mean absolute percentage error (MAPE) This test is calculated according to the following formula:

$$\mathrm{MAPE} = \sum_{t=1}^{T}\frac{\left|\frac{e_t}{y_t}\right|}{T} * 100$$

The best model for prediction is chosen when the MSE and MAPE values are as low as possible.

D- Forecasting

One of the primary goals of time series analysis is to predict future values. This stage is the final stage of the Box-Jenkens model, where future predictions of time series are accurate and valid if a sound model is selected and passes the testing and diagnosis stage.

After determining the ranks of the appropriate model (p, d, q) and ensuring that it is the best model according to previous tests, it is then used in prediction, by placing the current and previous values of the dependent variable y_T and the residuals e_T as estimated values for the error term on the right of the function, in order to obtain the first predicted future value y_{T+1}, which is called prediction for one future period. The second future value y_{T+2} can be obtained by placing the first future value y_{T+1} that was reached in the first step of prediction in the model equation, and thus prediction is made for subsequent future periods [Pfaff, 2008].

Predictive Study

This section will use ARIMA models to predict the exchange rate of the ID against the US dollar by following the following steps:

1- Detecting the Presence of Seasonal Components

Before studying the time series, it is necessary to determine the presence or absence of seasonal components that affect the study results. If the time series is found to contain seasonal components, they must be removed and their stability then examined. To detect seasonal components, both the seasonal graph and the Castle-Wallis test will be used. For accurate study results, seasonal components must be removed, as shown in Figure 2. We note that the averages are approximately equal, indicating the absence of seasonal components, but this is not sufficient. Therefore, the Castle-Wallis test was used after removing the seasonal components. This is shown in Table 3.

2- Studying the stationarity of the time series

After removing the seasonal components, it is necessary to study the stationarity of the time series. This is because if the time series is not stationary, it will give us inaccurate results. To determine the extent of the stationarity of this series, the Dickey-Fuller test was used, as shown in the following table.

Table 2. Dickey Fuller test for exchange rate test series.

UNIT ROOT TEST RESULTS TABLE				
Null Hypothesis: the variable has a unit root				
	At Level		**At First difference**	
				d(EXCHSA)
With Constant	t-Statistic	0.6328	t-Statistic	-6.1408
	Prob.	***0.8815***	***Prob.***	***0.0002***
		n0		***
With Constant& trend		-0.5583	t-Statistic	-6.2052
	Prob.	0.9400	***Prob***	0.0003
		n0		***
Without Constant& trend	t-Statistic	4.9417	t-Statistic	-5.1088
	Prob	1.0000	***Prob***	0.0001
		n0		***

We notice from the table above that the time series is not stationary at the level, as the Prob value for all models is greater than 5%, which confirms that it is not stationary.

3- Determining the prediction rank

The autoregressive (AR) rank and the moving average (MA) rank are determined using SPSS by AIC value, as shown in the table below.

Table 3. Both Rank of (AR) and (MA).

Automatic ARIMA Forecasting
Selected dependent variable :D (EXCHSA)
Date: 03/14/22 Time: 02:00
Sample: 2022M01 2025M04
Included observations: 49
Forecast Length :0
Number of estimated ARMA models :27
Number of non- converged estimations :0
Selected ARMA model: (2,4)(0,0)
AIC value:5.304783

The table above shows that the rank is (2.1.4) where the degree of autoregression is (AR=2), the degree of moving averages is (MA=4).

4- Study Form

After the rank has been determined, the study form must be included as shown in the table below.

Table 4. Study model.

Dependent Variable: D(EXCH)				
Method :ARMA Maximum Likelihood(BFGS)				
Date: 03/14/22 Time : 02:00				
Sample:2022M02 2025M04				
Included observations :47				
Convergence achieved after 93 iterations				
Coefficient covariance computed using outer product of gradients				
Variable	**Coefficient**	**Std.Error**	**t-Static**	**Prob.**
C	0.916012	0.074019	10.02313	0.0000
AR(1)	1.851129	0.032931	51.85653	0.0000
AR(2)	-0.928432	0.025773	-30.19910	0.0000
MA(1)	-4.071059	124.2475	-0.017024	0.9573
MA(2)	0.761131	138.9475	0.005373	0.9756
MA(3)	0.642258	29.35433	0.020484	0.9838
MA(4)	-0.359764	53.87830	+0.008199	0.9935
SIGMASQ	2.879076	300.3798	0.007266	0.9942
R-squared	0.619576	Mean dependent var		1.250851
Adjusted R-squared	0.656949	S.D . dependent var		2.197508
S.E of regression	1.827488	Akaike into criterion		5.304783
Sum squared resid	141.3626	Schwarz criterion		3.709815
Log likelihood	-101.3720	Hannan-quinn criter		5.522581
F-statistic	4.591154	Durbin- Watson stat		1.818260
Prob(F-statistic)	0.003877			
Inverted AR Roots	93-.19i	.89+.18i		
Inverted MA Roots	1.00-.07i	1.00+.07i	.64	-.66

We note from the table above that the values of the constants AR_1 and AR_2 are significant, while the other values are not significant, and therefore the prediction is made based on the significant values.

5- Prediction

This represents the final stage of the Box-Jenkens methodology. After determining the appropriate model for the data, it is used to determine the future values of the phenomenon. After performing the prediction, the values shown in the table below.

Table 5: Prediction results .

Modele		**Mai 2022**	**Juin 2022**	**Juil 2022**	**Aout 2022**	**Sept. 2022**	**Oct. 2022**	**Nov. 2022**	**Dec. 2022**
EXCH-Modele-1	Prevision	129.09	130.91	132.73	133.57	134.32	135.27	137.14	133.02
	UCL	133.18	134.10	130.38	142.28	153.84	141.44	136.83	158.14
	LCL	129.00	126.63	123.09	124.86	126.86	127.11	125.46	122.90

The estimated value was obtained from the table above, and the highest value that can be obtained in May is 133.18 dinars per dollar, and the lowest value is 129.00 dinars per dollar, while the forecast value is 129.09.

4. Conclusion

We were able to determine that the Box-Jenkens methodology is one of the most effective forecasting methods. The exchange rate series suffers from seasonal components because demand changes from one season to the next depending on the need. Therefore, seasonal components were removed to avoid affecting the forecast results. Through the stages of the Box-Jenkens methodology, the integration rank was set at 1 because the series is stable in first differences. The degree of autoregression was set at 2, and the degree of moving averages was set at 4, regardless of the model used in the study (2.1.4).

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