TURKISH LIRA EXCHANGE RATE FORECASTING USING TIME SERIES MODELS

Marwan Abdul Hameed Ashour [1] and Iman A.H. Al-Dahhan[2*]
[1]Prof. Dr., University of Baghdad, Iraq, dr_marwan2012 @yahoo.com
[2]Assist. Prof. Dr., University of Baghdad, Iraq, emanaldahhan@gmail.com
*Corresponding author

Abstract

Financial markets in any country in the world are one of the most important pillars of the economy. The global financial crisis and the current economic and political situation have impacted the regional and international financial markets. . To deal with such financial crises in the business markets, a model is essential to describe and address these phenomena which consider variations over time and characterize a suitable and effective model. The aim of this research is to construct a mathematical model for the time series of the Turkish lira compared to the US Dollar by the ARIMw model and to predict the next period, And to measure the accuracy and harmonization of the mode of prediction adopted using statistical error criteria.

Keywords: Time series models, Lira exchange rate prediction, financial markets, ARIMA models.

1. INTRODUCTION

Recently quantitative methods have turned into an urgent necessity to forecast financial markets and improve decisions and investments. Time series forecasting is considered as a very useful prediction method in which the previous observations are obtained and evaluated for the same constraint or phenomenon to construct a model which explains the basic relationship and then using the model to extrapolate the time series in the future.

The exchange rate is a relative price that measures the value of the local currency in terms of another currency. The exchange rate is one of the most effective variables in the financial environment for economic decision-makers and financial managers.

The importance of research stems from the fact that it is one of the leading researches of its kind to know the model and shape of exchange rate as one of the most important applications of modern time series prediction.

At present, though there are various models of financial forecasting that can be obtained, but accurate forecasts of the rate of exchange is not an easy task and The utmost relevant research studies that used ARIMA models to predict exchange rates; [1] [3] [4] [5] [6] [9]

The goal of this research is to adopt the best time series model using the Box-Jenkins methodology to build a prediction model at the exchange rate of the Turkish lira against the US dollar. The statistical standards were built on the RMSE and the absolute error rate (MAPE) to measure the accuracy and quality of the prediction method.

The research hypothesis states that the historical data behavior of the time series of the Turkish lira exchange rate follows the ARIM of the autoregressive model type P. The chronological limit of the study represents the time from 1/2/2018 to 30/6/2018. The spatial limit represents the daily exchange rate of the Turkish lira. The construction of the study is distributed in four key sections: the first is presented to the abstract and the preamble and the limits of research. The second division presents a theoretical basis for the study subject associated to the theoretical structure of time series. The third division presents the application side of the research. The fourth division presents the best significant findings and conclusions reached through this research .his is the main reason that research in this area did not stop to get more accurate results.

The most relevant research studies that used ARIMA models to predict exchange rates [1,3,4,5] [6,8,9]

This paper aims to adopt the best time series model using the Box-Jenkins methodology to build a prediction model at the rate of exchange of the Turkish lira against the US dollar. The statistical parameters have eliminated the RMSE and the absolute error rate of MAPE to measure the accuracy and quality of the prediction method. The research hypothesis states that the historical data behavior of the time series of the Turkish lira exchange rate follows the ARIM of the autoregressive model type P. The time limit of the research represents the period from 1/2/2018 to 30/6/2018. The spatial limit represents the daily exchange rate of the Turkish lira. The structure of the research is divided into four main section : the first is presenting the abstract and the preface and the limits of research. The second section presents a theoretical basis for the research topic related to the theoretical structure of time series. The third section is presented to the application side of the research. The fourth section presents the most important findings and conclusions reached through this research.

The importance of the research: The importance of this research stems from being the leading research of its kind to know the model and shape of exchange rate one of the most important applications of modern time series prediction.

At present, although there are many models of financial forecasting that can be obtained, but accurate forecasts of the rate of exchange is not an easy task and this is the main reason that research in this area did not stop to get more accurate results.

Research Objective: This paper aims to adopt the best time series model using the Box-Jenkins methodology to build a prediction model at the exchange rate of the Turkish lira against the US dollar. The statistical standards were based on the RMSE and the absolute error rate (MAPE) to measure the accuracy and quality of the prediction method.

Research Hypothesis: The hypothesis of the research indicates that the historical data behavior of the time series of the Turkish lira exchange rate follows the ARIM of the autoregressive model type P.

The research limit: The chronological limit of the research represents the period from 1/2/2018 to 30/6/2018 the spatial limit representing the daily exchange rate of the Turkish lira.

Structure of the research: The structure of the research is divided into four main sections are: the first presented the abstract, the preface, and the limits of research. The second section presents a theoretical basis for the research topic related to the theoretical structure of time series. The third section is presented to the application side of the research. The fourth section presents the most important findings and conclusions reached through this research.

Related studies: The most relevant research studies that used ARIMA models to predict exchange rates (Bai 2015; C 2014; Gupta et al. 2016; Khashei, Ali, and Bijari 2015; Liu 2014; Pedram 2015; Rout et al 2014).

2. LITERATURE

The time series is defined as a set of random observations generated over time according to probabilistic laws, from a mathematical point of view. In other words, it is a set of observed values taken over time periods [Z1, Z2, ..., Zn], This set is the specific section of the sequence . There are also two trends in the analysis of the time series:

The first trend: Time Domain Analysis the Auto-Covariance Generating Function and the Auto-Correlation

Function are used in this direction, and are referred to as ACF and Partial Self- Auto-Correlation Function referred to as (PACF). sequence.

The time series is a linear compound with successive limits of independent random errors and matching distribution which was used in the present study [2 , 7].

The second trend: Frequency Domain Analysis depends on the Spectrum Function and is called spectral analysis.

2.1. Auto-Correlation Function (ACF)

The Auto-Correlation function (ACF) is used to determine the appropriate model for the stable time series. The most important methods in determining the stability of the time series as well as the arithmetic mean and the constant variance if the coefficient of Auto-correlation between time series values at two points of time depends on the lag period (k) between them and does not depend on the time (t) itself, the series is stable [2] .

$$\hat{\rho}_k = \frac{\hat{\gamma}_k}{\hat{\gamma}_0} = \frac{\sum_{t=1}^{n-k} \left(Z_t - \bar{Z}\right)\left(Z_{t+k} - \bar{Z}\right)}{\sum_{t=1}^{n} \left(Z_t - \bar{Z}\right)^2} \ldots\ldots(1)$$

Where the $\bar{Z}$ Represents the sample mean for the time series Z_t .

$$\bar{Z} = \frac{\sum_{t=1}^{n} Zt}{n} \ldots\ldots(2)$$

2.2 Partial Auto-Correlation Function (PACF):

The Partial Auto-Correlation Function represented by (PACF) is used to determine the appropriate model for the stable time series. The partial Auto-correlation function is defined as the coefficients ϕ_{kk} of the Auto-correlation between Z_t , Z_{t+k} , after removing the effect of $Z_{t+1}, Z_{t+2}, \ldots, Z_{t+k-1}$ [1, 2 , 7]

So:

$$Corr\left(Z_t, Z_{t+k} / Z_{t+1}, Z_{t+2}, \ldots, Z_{t+k-1}\right) \ldots(3)$$

They are calculated according to the following formula:

$$\rho_i = \phi_{k1}\rho_{i-1} + \phi_{k2}\rho_{i-2} + \cdots + \phi_{kk}\rho_{i-k}, \; i = 1, 2, \ldots, k$$

2.3 Box-Jenkins Methodology

The process of constructing the ARIMA model (p, d, q) to represent and use time series data for prediction purposes is called the Box-Jenkins method. This method is one of the general methods for predicting different types of time series (stable and unstable, seasonal and non-seasonal)

Because it does not assume that, a certain pattern exists in the string data prior to its application, as is the case with other prediction methods (eg, exponential boot methods) Rather, it begins with a pilot model determined by ACF and PACF functions. The parameters are then estimated based on time series observations to make forecast errors as low as possible, In this method, a number of indicators are adopted to make the researcher able to judge whether the model is appropriate or not The best predictor of the value of Xt in time t + L which follows the general mixed model [2]

Φp(Bs) Φp (B)(1-B)d (1-Bs)D Xt= ΘQ (Bs) θq(B) at ……… (4)

Where (s) the length of the seasonal period is (conditional expectation) " where:

$\hat{X}$t(L)=E [Xt+L Xt , Xt+1 , …….] ………. (5)

When model (9) becomes stable, it can be rewritten in terms of random errors and as follows:

Xt =Ψ (B) at= at + Ψ1at-1+Ψ2 at-2 +….

= ΣΨJ at-J ,Ψ0=1 ……. (6)

Therefore, the future error prediction "forcate error" can be written as:

et(L)=Xt+L-$\hat{X}$t(L)=11ΨJ at+L-J ………… (7)

2.4 The stages of building the model according to the Box-Jenkins method:

In 1970, both Box and Jenkins proposed this method. Although the methodology of many of these stages was known before 1970, the Box-Jenkins first united these steps in the style identified by their names. The stages of the Box-Jenkins model are:[1, 2, 6, 7]

2.4.1 Diagnosis

The stage of diagnosis of the model is one of the important and difficult stages to reach the appropriate model. The main task of this stage is to diagnose and test the best model, which represents the time series of the ARMA (p, q) or ARIMA (p, d, q) models using the Auto-correlation and partial Auto-correlation factors. If the coefficients of the Auto-correlation function are decreasing exponentially and the partial Auto-correlation coefficients are interrupted after the interval (p), the model is AR (p), and if the Auto-correlation coefficients decrease exponentially and the Auto-correlation coefficients are broken after the interval q, the model is MA (q). In the case of ARMA (p, q), the Auto-correlation coefficients and the partial Auto-correlation coefficients are usually exponential.

Table (1) includes Summary of the different patterns of Auto-correlation and Partial Auto-correlation functions for the non-seasonal Models.

Table (1) Diagnosis of the ARMA model

partial Auto-correlation ***PACF***	Auto-correlation functions ***ACF***	Model
AR(p)	exponential.	cut after p lag
MA(q)	cut after q lag	exponential.
ARMA(p,q)	exponential.	exponential.

2.4.2 Estimation

There are several methods for estimating model parameters, some depending on the probability distribution of the time series. These methods are: Exact Maximum Likelihood, Approximate Maximum Likelihood, and methods that do not depend on the probability distribution of the time series, are The Least Square Method, also regularly efficient software is used efficiently for this purpose.

2.4.3 Diagnostics

At some stage, the estimation of the parameters of the model is the procedure for checking whether the model is appropriate or not. In addition, are the residuals white noise.

2.4.4 Prediction accuracy

To measure the accuracy of the results of the approved methods, the statistical criteria adopted were: RMSE And the absolute rate of error ratio MAPE under the following formulas [1,3,7]

$$RMSE = \sqrt{\frac{\sum et^2}{n}} \dots .(8)$$

$$MAPE = \frac{\sum \left| \frac{et}{Xt} \right|}{n} * 100 \ldots..(9)$$

3. THE PRACTICAL PART

Figure 1 represents the daily rate of exchange of the Turkish lira against the dollar for 150 days for the period from 1/2/2018 to 30/6/2018 (source data: the Wall Street website).

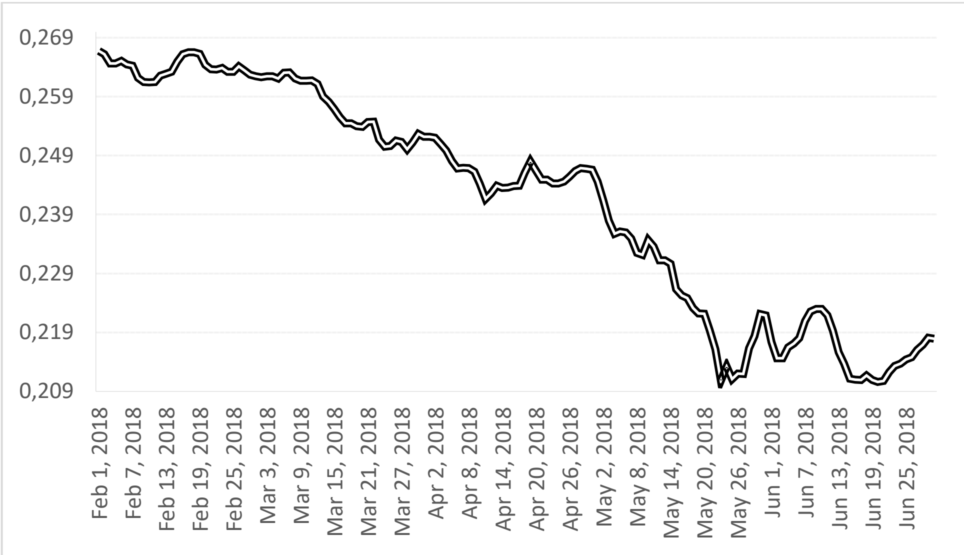

Figure (1) Series of exchange rate of the Turkish lira for the period 15/5/2017 - 10/11/2017.

Figure 2 illustrates the behavior of the Auto-correlation and partial correlation coefficients of the time series in question calculated through SPSS program version 21.

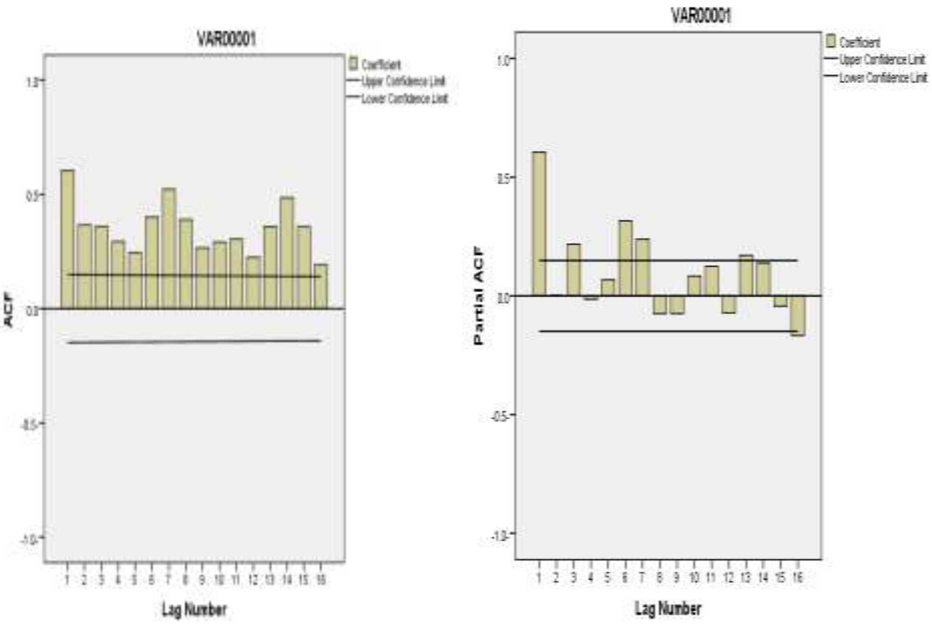

Figure (2) The behavior of the Auto-correlation and partial correlation of the time series

4. RESULTS

The behavior of ACF and PACF shows that the Auto-correlation function decreases exponential and the partial Auto-correlation function involves a cut in the first LAG. Based on the ARMA model diagnosis methodology in Table 1, the best ARMA model for the time series under research is ARIMA (1,0,0). The ARIMA model was estimated using SPSS version 21, and the results of the model parameter estimate shown in Table (2) are shown to be significant.

Table (2) Estimation of model parameters

Estimation Parameters		**Asympt. Std. Err.**	**Asympt. t(178)**	**p-value**
Constant	1.407693	0.000667	2111.697	0.000
ϕ	0.632879	0.58445	10.829	0.000

Thus, the mathematical model is illustrated in equation (10).

$$x_t = 0.632879x_{t-1} + \epsilon \quad \dots\dots..(10)$$

It is clear from Sloan that the Auto and PACF Of the residues is a random behavior as presented in Fig. 3 indicate the value of the Ljung-Box test in Table (2) as significant for the sequence in Fig. 4. The estimated model is appropriate and the best.

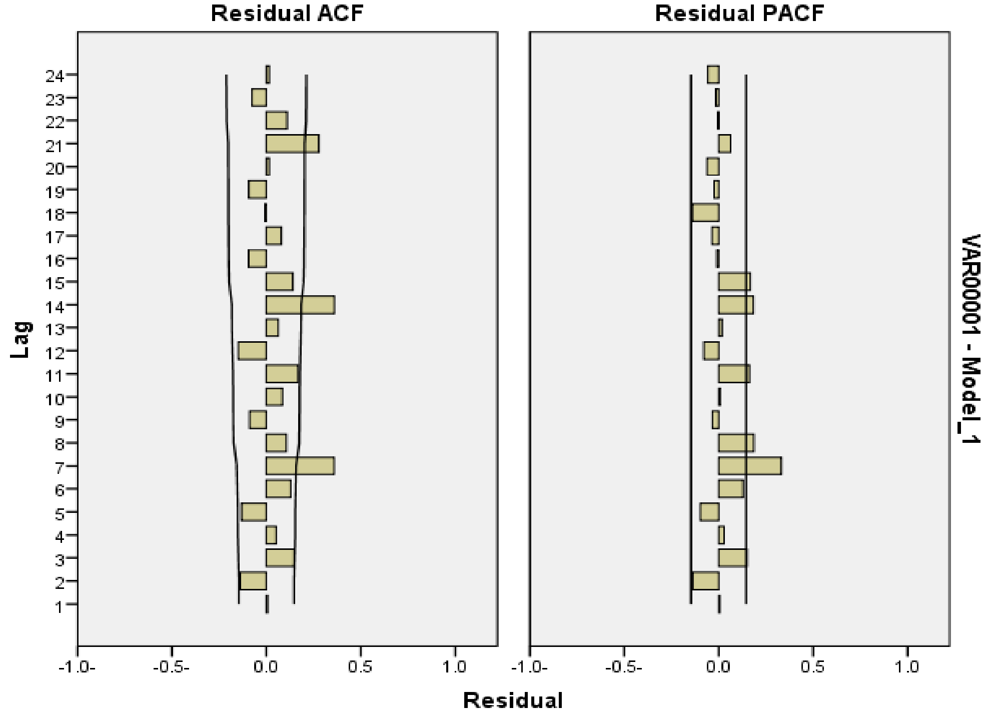

Figure (3): Performance of the Auto and partial bonding performance of the residues

Table (3) Test outcomes of the model

Model	Number of Predictors	Model Fit statistics			Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	RMSE	MAPE	Statistics	DF	Sig.	
Model_1	0	.375	.001	.047	86.461	17	.000	0

Table (4) shows the results of the accuracy of the prediction method, the efficiency, quality and harmonization of the estimated model.

Table (4) Results of error accuracy criteria

Fit Statistic	RMSE	MAPE
	.001	.047

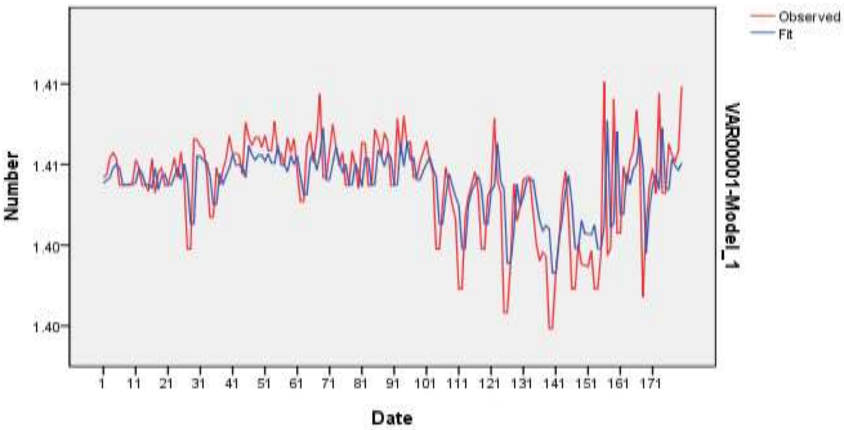

Figure (4) the conciliation path of the series in question

Table (5) shows the prediction values for the twelve-day period ahead of July 2018

Table (5) Prediction values for the future period

CaseNo.	Forecast	Lower 90.0000%	Upper 90.0000%
181	1.4092	1.4037	1.4146
182	1.4086	1.4021	1.4151
183	1.4083	1.4014	1.4151
184	1.4081	1.4011	1.4151
185	1.4079	1.4009	1.4150
186	1.4078	1.4008	1.4149
187	1.4078	1.4007	1.4149
188	1.4078	1.4007	1.4148
189	1.4077	1.4006	1.4148
190	1.4077	1.4006	1.4148
191	1.4077	1.4006	1.4148
192	1.4077	1.4006	1.4148

5. CONCLUSIONS

This research main findings can be outlined as follows: two design measures, RMSE and MAPE,, were adopted for the purpose of evaluating and testing the quality and effectiveness of an approved prediction method. The results indicated that the best time series model representing the exchange rate of the Turkish lira compared to the dollar is ARIMA (1.0,0). The degree of harmonization of the model is high founded on the conciliation curve and the randomness of the residues. This model shows that the time series is stable. As the results proved, the hypothesis of this study was achieved since the time series in question followed the regression model of the first degree. Therefore, we recommend following the mathematical model in Equation (1) in building the financial and economic plans and strategies in the Jordan and also to predict the percentage of the dinar exchange rate against the dollar or the euro.

REFERENCE LIST

[1] Bai, Yaohui. 2015. "A Modified ARIMA Model Based on Extreme Value for Time Series Modelling." (Meic): 1197–1200.

[2] Box, George E P, Gwilym M Jenkins, Gregory C Reinsel, and Greta M Ljung. 2015. *Time Series Analysis: Forecasting and Control*. John Wiley & Sons.

[3] C, Nwankwo Steve. 2014. "Autoregressive Integrated Moving Average (ARIMA) Model for Exchange Rate (Naira to Dollar)." 3(4): 429–34.

[4]Gupta, Sanjeev, Sanjeev Gupta, Sachin Kashyap, and Sachin Kashyap. 2016. "Modelling Volatility and Forecasting of Exchange Rate of British Pound Sterling and Indian Rupee." *Journal of Modelling in Management* 11(2): 389–404.

[5] Khashei, Mehdi, Mohammad Ali, and Mehdi Bijari. 2015. "Comparison of Four Interval ARIMA-Base Time Series Methods for Exchange Rate Forecasting." (July): 21–34.

[6] Liu, J J. 2014. "A Multiscale Modeling Approach Incorporating ARIMA and Anns for Financial Market Volatility Forecasting." (June 2015).

[7] Moosa, I. 2016. *Exchange Rate Forecasting: Techniques and Applications*. Springer.

[8] Pedram, Mehdi. 2015. "The Effects of Economic Variables on Exchange Rate , Modeling and Forecasting : Case of Iran." 3(1): 13–23.

[9] Rout, Minakhi, Babita Majhi, Ritanjali Majhi, and Ganapati Panda. 2014. "Forecasting of Currency Exchange Rates Using an Adaptive ARMA Model with Differential Evolution Based Training." *Journal of King Saud University-Computer and Information Sciences* 26(1): 7–18.