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Forecasting stock prices using the Box-Jenkins methodology: a case study of the Bank of Baghdad

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Abstract : The research aims to predict the prices of Bank of Baghdad shares listed on the Iraqi Stock Exchange using the Box-Jenkins methodology, one of the time series models, as it was and still represents an intellectual and practical debate about the superiority of this model in predicting stock prices, as the Box-Jenkins model requires the presence of stability in... To apply the time series, we used the annual closing price data announced in the Iraq Stock Exchange for the Bank of Baghdad for the period from (1/1/2011) until (12/31/2022) and then forecast for two years (2023-2024), and many programs were used To reach accurate results, the research reached a set of results, the most important of which is a model Box-Jenkins can predict the annual closing prices of Bank of Baghdad listed shares In the Iraq Stock Exchange, the research concluded with several recommendations, the most important of which is the use of box models - Jenkins When conducting statistical analysis of time series values, through these models it is possible Obtaining the most efficient models to predict the prices of the Bank of Baghdad listed on the Iraqi Stock Exchange Finance.
Keywords: Stock prices, time series, Box-Jenkins model

Introduction:

Stocks are the most important financial instruments traded and the basic pillar in the capital markets. Predicting stock prices is an important process that has a prominent role in the decision-making process. It is important in making economic decisions and planning for the future. Although investing in stocks achieves high returns, On the other hand, it faces a high degree of risk. The process of predicting stock prices is characterised by difficulty and complexity because it depends on many factors, including political, economic, and financial, which decide to invest in stocks timely. There are many ways to predict stock prices that rely on methods. Statistical and mathematical methods, including the Box-Jenkins method, can predict accurately. Many studies have been conducted to test the models, their capabilities, the accuracy of their results, and their impact on investor profitability, in addition to an attempt to develop software more capable of completing the task with the best possible results. The research comes as an attempt to test the capabilities of the Box-Jenkins model. It is applied to the Bank of Baghdad listed on the Iraq Stock Exchange Finance.

Problem Statement: The research problem centres on the possibility of the Box-Jenkins model to predict the stock prices of the Bank of Baghdad Listed on the Iraq Stock Exchange, the research problem is formulated as follows: (What extent is the Box-Jenkins model able to Predict the annual closing prices of Bank of Baghdad a Stock?)

The Aims of the Study: the study aims at achieving the following objectives:

1- Explaining the predictability of stock prices for the Bank of Baghdad listed on the Iraq Stock Exchange Using the Box-Jenkins method.

2- Help rationalize investment decisions by providing reliable results and Predicting stock prices.

3- Increasing the accuracy of forecasting stock prices by forecasting time series of stock prices Generated from the Box-Jenkins model.

The Significance of the Study: The study derives its importance from the significance of the variables that it handles which are represented as follows:

1- Keeping pace with the rapid development and how to benefit from this development in predicting bank Stock prices in Baghdad.

2- Providing scientific guidance that helps investors choose the stock in an accurate and simplified manner To some extent, investor confidence in using forecasting models increases.

3- Time is a crucial factor in the stock trading process, so it needs to be as quickly as possible in order to Get information to avoid sudden price changes.

(II):- The Hypothetical Scheme of the Study:

After addressing the problem, importance and objectives of the research, it is necessary to build a model in which it can clarify the nature and type of relationship between the research variables, see Figure (1):

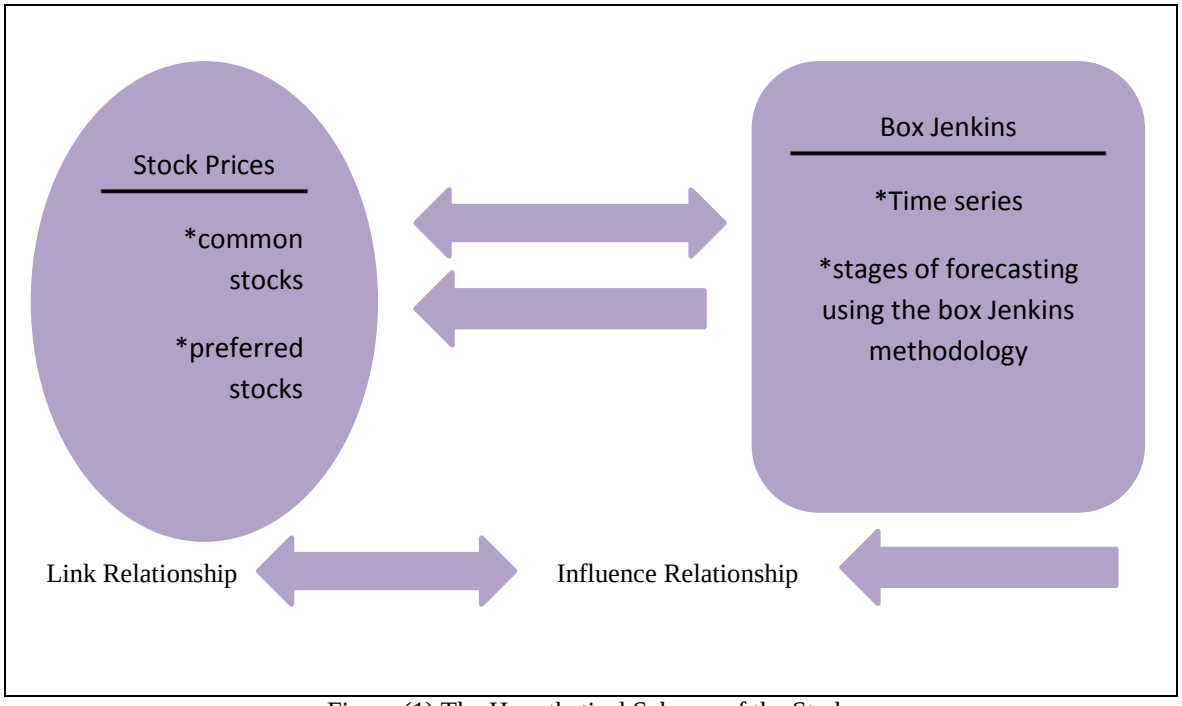

Figure (1) The Hypothetical Scheme of the Study

(III):- The Hypotheses of the Study:

According to the question stated in the problem, the following hypothesis can be made:

- **Correlation Hypothesis**
- H0: The Box-Jenkins model cannot predict the annual closing prices of stock Consumption in Baghdad.
- H1: The potential of the Box-Jenkins model in estimating the prediction of the annual closing prices of bank stocks in Baghdad.

(IV):- The Community and the Sample of the Study

1- Time limits: The research period extends from (1/1/2011) until (12/31/2022) and at a rate of annual.

2- Spatial borders The spatial borders were represented by the Bank of Baghdad listed on the Iraq market For securities.

The second topic:-

First: - Stock Concept

The share refers conventionally to the partner's share in the company's money or the instrument that represents the partner's share in the company's money as proof of his right. (Al-Osaimi,724:2020), and (Al-Shabib,48:2009) defined it as an ownership instrument characterized by a degree of security in terms of the nature of the income, as the Stocks have unstable returns that change depending on the production and profit achieved by the company. They are characterized by a higher degree of risk than bonds. (Al-Hasnawi,104: 2014) also defined them as a financial tool to provide capital for huge projects that need large amounts of money, and they can only be provided by resorting to a large number of investors, and stocks It is the capital in joint stock companies.

1- Types of Stocks

The financial market environment today contains many types of stocks, but the most common ones are stocks Preferred and common shares are as follows:

A- Common Stocks

These stocks represent the main tool for financial investment, as most of the stocks traded in Capital markets are common stocks (Sanders, Cornett, 2012:245), and common stocks are A type of securities that companies issue to investors in exchange for their investments, as it gives shareholders Ownership rights, and each shareholder must have

at least one share, and in general there are no restrictions on this It relates to the maximum number of shareholders in the company (Parameswararm,97:2011)

The holder of the common share enjoys some rights and obligations: (Al-Hasnawi,93:2017)

1- The holder of the common share has the right to vote in the general assembly and choose the board of directors.
2- The holder of the common share has the right to monitor the company's performance and review the records and lists Accounting.
3- The holder of a common share cannot redeem the value of his shares from the company, but he can sell them in a market Securities, specifically in the secondary market.
4- The holder of ordinary shares cannot claim a share of the profits unless the company decides to distribute them.
5- In the event of the company's bankruptcy, there is no guarantee that the value of the common shares will be recovered Some of it is recovered if the equity does not cover the company's debts.

B - **Preferred Stocks**

Preference shares are a long-term investment instrument, and are known as an ownership instrument because they are Securities grant ownership rights to common stock shareholders, but they differ from the owners of the shares Preferred shares have some benefits that common stock owners do not enjoy, such as return value Their shares when the company is liquidated by ordinary shareholders, as well as by receiving distributed profits Preferred stockholders have priority in that (Brigham and Daves 297: 2016), as the shares Preference is one of the forms of ownership in joint-stock companies, and differs from ordinary shares by the preference of the holder The holder of the common stock must obtain profits and obtain the value of his shares upon the liquidation of the company. The returns of preferred stockholders are often represented by a percentage of the total preferred stock. In contrast, holders of preferred stock do not have voting rights in the general assembly or participation in Administrative decisions (Ross et al, 2003:256)

Characteristics of preferred stock (Alver, 2007:44)

1- The rate of return on the preferred stock shall be fixed and guaranteed and determined in advance.
2- Voting rights are not granted to shareholders to elect a board of directors or vote on anything.
3- Preferred stocks are less risky than common stocks.
4- Preferred shares are less expensive to issue than ordinary shares.
5- The holders of preferred shares have priority over the company's profits, and in the event of the company's bankruptcy, it is paid They receive profits before ordinary shareholders.
6- Holders of preferred shares can convert their shares into ordinary shares.

Second: -

Time Series

Time series analysis is based on the basic assumption that "what was in the past can be It will be repeated in the future," despite prevailing beliefs that what happened in the past cannot be repeated Completely, as a result of the dynamic nature of the future, and its dependence on past events to some extent They occur repeatedly in the future, so future events can be predicted by using chain models Temporality (Nugus, 2009:61)

The most famous and widely used time series models in forecasting are the following:

1- Autoregressive model (AR)

It is defined as the regression of the current value of the series on the values of the same series in previous periods (Gökbulut et al. 2011: 152). It represents the correlation of the current observations of the time series with the observations of the previous series and is used in describing various fields of phenomena, whether natural or economic. In other words, when the value The current value of the time series is a function of its value over the previous period, in addition to some errors. The model formed from this process is autoregressive (24, 2018, Al-Sarhan)

2- Moving Averages model (MA)

A moving average model reports the current value of a time series as a function of the previous value The current values are for the random error values, meaning that the model depends on the random error of the time series (Ahmad,2017: 23)

3- Autoregressive model and moving averages mixed model (ARMA).

In this model, the autoregressive model and the moving averages model are combined, including Characteristics of the two types to obtain a model that has more flexibility in representing series data Temporal, and the model is symbolized by PA (ARMA), which is considered the rank of the model, and this model can be benefited from It reduces the number of parameters needed to build a model of a series, and is characterized by great flexibility in representation Time series data, and it is considered one of the commonly used models in all areas of life (Ghofrani & Suherli, 2017:82-84)

4- Integrated Mixed Model (ARIMA)

The researchers (Box & Jenkins) described the ARIMA model more accurately and comprehensively by developing a method for understanding instability and treating it because the time series is unstable from the average, as it is converted into a stable time series, and this is done by taking the necessary differences for it, and the model is symbolized (ARAM) after taking Differences for time series with the symbol (ARIMA) (Majid, 2012 (36). It is one of the most widely used time series models, as all models can be derived, namely moving averages, autoregressive and mixed model, and it is considered the most common in predicting the values of variables Economic matters such as commodities, inflation, prices, stock returns, etc (Atwan, 2022:357).

The Third Topic: the practical side

First: - Describe and Analyze the Data

The research deals with describing and analyzing the research data to achieve its objectives and test its hypotheses based on the stock prices of the Bank of Baghdad for the period from (1/1/2011) until (12/31/2022) according to the Box-Jenkins model, and the data was analyzed according to the research variables, which are the independent variable represented by Box Jenkins, and the dependent variable represented by stock prices. We relied on the primary data shown in Table (1), which is represented by the stock prices of the Bank of Baghdad.

Table (1) Bank of Baghdad stock prices for the period (2011-2022)

Year	Opening	Highest price	Lowest price	Current rate	Closing price	Previous Closing	Earnings Stock
2011	1.830	4.150	1.830	3.130	3.480	1.790	0.94
2012	3.480	3.500	1.370	1.960	1.800	3.480	-0.48
2013	1.750	2.220	1.510	1.850	2.060	1.800	0.14
2014	2.030	2.150	1.220	1.731	1.550	1.700	-0.09
2015	1.540	1.590	0.990	1.310	1.170	1.550	-0.25
2016	1.130	1.130	0.600	0.820	0.910	1.170	-0.22
2017	0.900	1.190	0.550	0.710	0.610	0.910	-0.33
2018	0.610	0.730	0.290	0.940	0.290	0.610	-0.52
2019	0.300	0.140	0.230	0.300	0.300	0.290	0.03
2020	0.310	0.520	0.260	0.380	0.410	0.300	0.37
2021	0.410	0.970	0.380	0.720	1.030	0.410	1.51
2022	0.010	1.490	0.970	1.230	1.370	1.030	0.33

Table (1) shows that the Bank of Baghdad achieved the highest annual closing price in the year 2011, which was (3.480) dinars, then it began to decline in subsequent years with varying declines, while the lowest annual closing price was in the year 2018, which was (0.290) dinars, and after that, it began to rise, and the figure shows (1) The movement of stock prices during the research period.

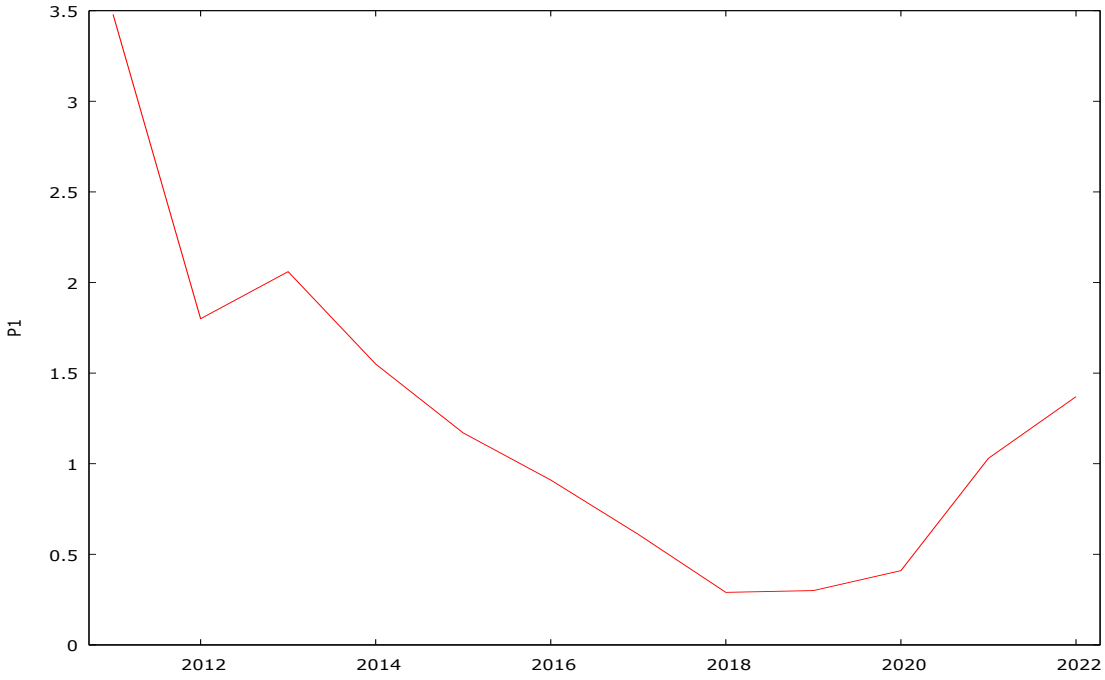

Figure (1) Movement of Bank of Baghdad Stock prices

Second: - Testing and analyzing hypotheses

Stock prices are characterized by continuous and fluctuating movement at the same time, which makes them constantly change as a result of the surrounding circumstances and events. In this section, the study's hypotheses will be tested and analyzed, represented by an attempt to predict the annual closing prices of the Bank of Baghdad shares listed on the Iraqi Stock Exchange according to the two Box-Jenkins methods.

Testing the main hypothesis: represented by:

H0: The Box-Jenkins model cannot predict the annual closing prices of stock Consumption in Baghdad.

H1: The ability of the Box-Jenkins model in estimating the prediction of the annual closing prices of bank stocks Baghdad.

Baghdad Bank

Table (2) shows the characteristics of the studied data. The arithmetic mean was 1.25, the minimum was 0.29, while the maximum values were 3.48, with a standard deviation, that is, the dispersion between the main values and their mean, 0.91, and a coefficient of variation of 0.73. The results are summarized in the following table:

Table (2)

Characteristics of the Bank of Baghdad date for the period (2011-2022)

Bank Symbol	Arithmetic mean	Minimum	Highest rate	S.D	C.V
BBOB	1.25	0.29	3.48	0.91	0.73

To determine the appropriate model for stock price data, estimate the model parameters, and test its adequacy Use it later to predict the future for the years 2023 and 2024.

After analyzing the data and based on the values of the AIC, SC, and HQ criteria, the appropriate model is the Autoregressive model (1)AR) as its values were the lowest compared to the set of models tested to be Then estimate the model parameters which are shown in Table (3) as follows:

Table (3)

Estimating the parameters of the model specified for the Bank of Baghdad data for the period (2011-2022)

Model 1: ARMA, using observations 2011-2022 (T = 12)

Bank Symbol		Coefficient	Std. Error	Z	p-value	AC	HQ	SC
BBOB	phi_1	0.96	0.04706	20.5411	0.00001	28.77457	28.41551	29.74439

The results showed that the model parameter value was (0.96) with a standard error of (0.047) and its test value 2 was equal to (20.5411), which is a value with moral significance because its p-value Equal to 0.00001, which is less than the specified significance level of 5%.

After testing the accuracy and efficiency of the model used based on the resulting error values, the results were reached The criteria in Table (4) for evaluating prediction.

Table (4)

Forecast evaluation statistics

Mean Error	Mean Squared Error	Root Mean Squared Error	Mean Absolute Error
0.15197	1.3108	1.1449	0.67264

To make the results more accurate, the values of autocorrelation ACF and partial autocorrelation PACF were found The errors of the model used in predicting stock prices, the results of which are shown in the following table (5):

Table (5)

ACF and PACF values for the residuals of the Bank of Baghdad model AR (1)

LAG	ACF	PACF	Q-Stat	[P-value]
1	-0.3321	-0.3321	1.6842	[0.194]
2	0.1351	0.0279	1.9910	[0.370]
3	-0.0602	-0.0082	2.0587	[0.560]
4	-0.0640	-0.1008	2.1448	[0.709]
5	-0.0500	-0.1103	2.2049	[0.820]
6	-0.0612	-0.1115	2.3098	[0.889]
7	-0.1083	-0.1828	2.7041	[0.911]
8	-0.0282	-0.1536	2.7376	[0.950]

Figure (2) shows the results achieved in Table (5).

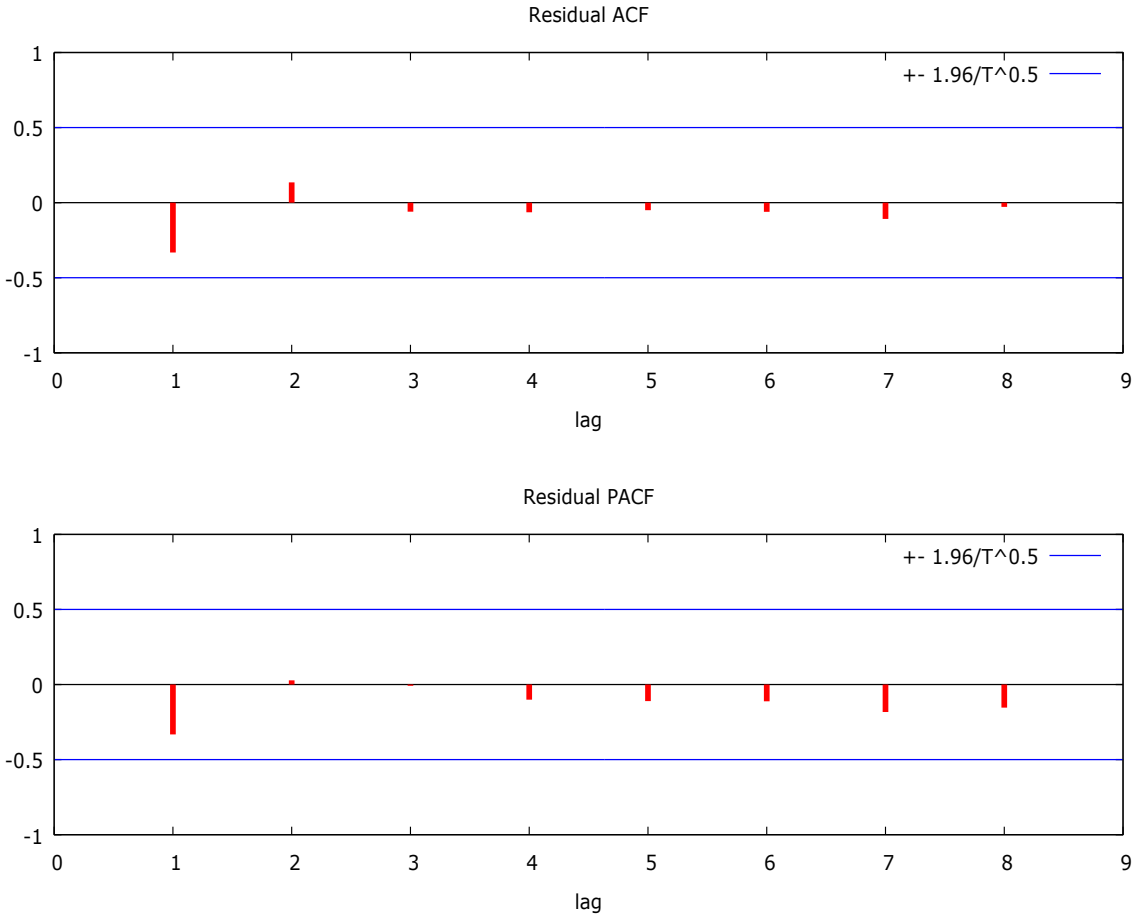

Figure (2) ACF and PACF values for errors in the Bank of Baghdad data model

After ensuring the suitability and efficiency of the model used to predict future stock prices of a bank Baghdad can be predicted for the next two years, 2023 and 2024, as shown in the following table (6):

Table (6)

Future predictive values of Baghdad Stock prices

For 95% confidence intervals, z(0.025) = 1.96

Obs	P1	Prediction
2023	Undefined	1.32433
2024	Undefined	1.28019

Figure (3) shows the accuracy of the results achieved through predictive and real stock prices 2023 and 2024.

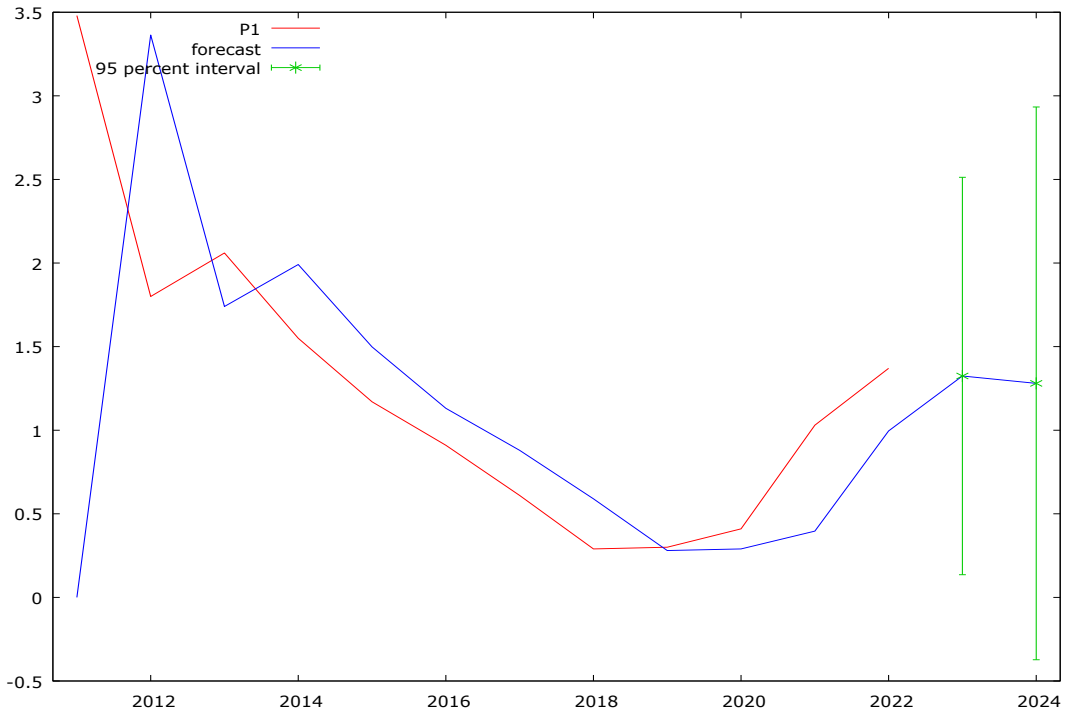

Figure (3) Real and forecast Stock prices for the Bank of Baghdad

From the above, it is clear that it is possible to predict the future stock prices of the Bank of Baghdad according to the Box Jenkins model, which indicates acceptance of the first alternative sub-hypothesis H1 and rejection of the null hypothesis H0.

The Fourth Topic: Conclusions and Recommendations:

First: - Conclusions

1- The Box-Jenkins method can predict stock prices in the Bank of Baghdad Listed on the Iraq Stock Exchange.

2- The emergence of new models to predict stock prices using an advanced statistical method.

3- Weak culture of predicting stock prices for traders in the financial markets, as most investors are Stocks in the Iraqi Stock Exchange rely on personal abilities, guesses, and rumours, and do not rely on modern methods and techniques in making trading decisions, except for the category Few.

Second: - Recommendations

1- Emphasizing the importance of forecasting stock prices in the Bank of Baghdad to rationalize the investment decision of Investors in the Iraq Stock Exchange.

2- Adopting the Box-Jenkins model in predicting stock prices in the Bank of Baghdad, because it is more Accuracy than other models.

3- The necessity of using the best stock price prediction models so that you can identify strengths And the weaknesses facing the stock market to take the necessary measures.

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