

Use the Box-Jenkins methodology To predict the financial crisis: A study of a sample of banks listed on the Iraqi Stock Exchange

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Abstract : The research aims to predict the financial crisis using the Box-Jenkins methodology, representing the research community in the banking sector in the Iraqi Stock Exchange, while the research sample consisted of (4) banks listed on the Iraqi Stock Exchange for a period of 12 years, from (1/1/2011).) until (12/31/2022), The statistical test represented by the Gretl program was used. The researcher reached a set of conclusions, the most important of which is the possibility of predicting the financial crisis using the Box-Jenkins methodology, and that the best model of the Box-Jenkins models is the (0,0,1) ARIMA model for all banks in the study sample, which is It was used to draw conclusions and predict the financial crisis based on it.

The research concluded with a set of recommendations, the most important of which is the commitment of Iraqi banks listed on the Iraqi Stock Exchange to the regulations and laws issued by the Central Bank in order to avoid banking crises and reduce the occurrence of banking risks in the future, in addition to conducting other studies to predict financial crises through other models of the Altman model, Kadi, Sherrod) And apply it in the Iraqi Stock Exchange to identify the phenomenon under study and its components and try to understand its behavior by studying historical data and then accurately predict the possibility of interpreting the relationship between the phenomenon and variables to enable planning, researchers and policy makers to make informed decisions based on quantitative and scientific methods so that they can be used effectively. At the lowest costs.

Introduction: Financial crises are not a recent phenomenon by any means, but rather they are often subject to the same forces that have long exerted their influence in various crises, and the banking crisis is a form of financial crisis, manifested in individuals rushing to banks to recover their deposits, due to the banking panic that dominates the... These individuals after they realized the state of the financial situation of those banks The efficiency of financial activity is one of the most important determinants of the bank's ability to achieve its goals of survival and continuity. The bank's mismanagement of the financial aspect may expose it to what is known as financial default, so it is often unable to meet its obligations and thus a financial crisis occurs.

Early warning indicators for banking crises are among the most important indicators of the health of the banking system. Many methods and models have emerged for the purpose of predicting financial crises, including the Box-Jenkins methodology, which our research focused on, which is a mathematical model designed to predict data based on inputs from a specific time series. This model consists of It has four stages: the recognition stage, the estimation stage, the testing stage, and finally the prediction stage. Accordingly, the research was divided into four sections. The first section included the research methodology, the second section included the theoretical aspect, and the section came to clarify the practical aspect. The fourth section included conclusions and recommendations.

The first section: research methodology

Research problem

The forecasting process in the financial crisis is directly affected by choosing the appropriate model for the data of that crisis, as this step directly affects the accuracy of the forecasts obtained, so the research problem is limited to how to build an accurate statistical model, through which the behavior and trends of the time series can be predicted, and from there came Main question:

(Is it possible to rely on the Box-Jenkins methodology as an early warning indicator to predict the financial crisis in the banks of the research sample listed on the Iraqi Stock Exchange?) From which came the following sub-question:

*Is it possible to predict the financial crisis according to the asset quality index using a methodology? Box-Jenkins

Research aims:

As a result of the importance and seriousness of the issue of banking financial crises and early prediction of their possibility, especially in light of the current circumstances surrounding the banking environment in the Iraqi Stock Exchange, this research aims to:

1- Study the financial positions of banks listed on the Iraqi Stock Exchange, and clarify whether they enjoy financial stability or not.

2- Testing the suitability of the Box-Jenkins model to measure the possibility of a financial crisis occurring for banks listed on the Iraqi Stock Exchange.

3- Study and analyze the development of the most important financial performance indicators of the Iraqi banking sector, which affect the possibility of the financial crisis occurring.

Research importance

In light of the current economic conditions, which Iraq is currently going through, and the resulting increase in the number of non-performing loans, and thus the high probability of financial default, it has become important to have an early warning indicator that represents an important tool for guidance and warning that decision-makers rely on to take the necessary measures.

From this standpoint, the importance of the research is evident in the following:

1- Developing a statistical model using the Box-Jenkins methodology as an early warning indicator, as it constitutes a tool for predicting the possibility of a financial crisis occurring, which will benefit all users of financial statements.

2- The possibility of benefiting the authorities, decision-makers in the state and Iraqi banks with the results of future forecasting in a simplified and accurate manner.

3- Increasing confidence in using similar prediction models through the results that the researcher has reached using the methodology. Box-Jenkins

research assumes

According to the questions stated in the study problem, the following hypotheses can be made:

Main hypothesis:

Null hypothesis:H0: It is not possible to predict the financial crisis using the Box-Jenkins methodology in the research sample banks listed on the Iraqi Stock Exchange.

Alternative hypothesis H1: The possibility of predicting the financial crisis using the Box-Jenkins methodology in the research sample banks listed on the Iraqi Stock Exchange.

From there it branches into the following:

Null hypothesis: HO: It is not possible to predict the financial crisis according to the asset quality index using the Box-Jenkins methodology.

Alternative hypothesis H1: The possibility of predicting the financial crisis according to the asset quality index using the Box-Jenkins methodology

Research population and sample

The research community represented the banking sector in the Iraq Stock Exchange, while the research sample consisted of (4) banks listed on the Iraq Stock Exchange for a period of 12 years, starting from (1/1/2011) until (12/31/2022).

Some previous studies

1- Study (Rahi 2021) “The financial crisis in Iraq and its impact on banking performance, an analytical study in the banking system for the period from (2008-” (2019)

The study aims to find out the reasons for the occurrence of the financial crisis and its impact on Iraqi banking performance through its indicators represented by (bank credit, bank deposits, banking investment), as the study population represents the Iraqi banking sector, as the study relies on the inductive approach that relies on descriptive analysis and analysis. Quantitative study of the variables of the study, and its results showed the necessity of paying attention to the indicators of the financial crisis and studying its causes through which the banking system can be protected from falling into crises in order to improve the services provided to customers and thus improve banking performance.

2- Study (Al-Taweel 2008) “The extent to which banks rely on financial analysis to predict default, an applied study on national commercial banks in the Gaza Strip.”

The study aims to clarify the importance of financial analysis to predict bank defaults, and to put the bank in a position that can continue to practice its activities in the future and correct the situation before default occurs. The study population represents the Palestinian banking sector, while the study sample represents the national commercial banks in the Gaza Strip, where the study is based. The data were analyzed using the statistical analysis program (SPSS), and its results showed that national commercial banks depend to a large extent on financial analysis in the aspect of evaluating performance and making decisions, and rely to a lesser extent on financial analysis in the field of predicting stumbling or financial failure.

3- Study (Liliana Rojas 1999) “Early warning indicators of banking crises for emerging markets: with applications for Latin America”

This study aims to analyze the causes of banking crises in Latin America and East Asian countries, as it represents the population and sample of the study in emerging markets in Latin America and East Asian countries. The study relied

on the quantitative method, and the results showed that the most widely used indicator of banking crises in industrialized countries is the ratio Capital to assets, and its performance was poor in Latin America and East Asian countries as an early warning indicator.

The second section: The theoretical aspect

First: the financial crisis

- The concept of financial crisis

There are many concepts for the financial crisis, as follows:

The first person to use the term “crisis” was Marx when he wrote in Economic Concepts about the contradictions of capitalism and its collapse. He mentioned that capitalist systems, due to their contradictions, will be exposed to crisis and then collapse. There is no specific definition of the financial or economic crisis, and some of them define it as The financial economic concept, and some of them define it as the concrete economic concept. It is defined (Curtle, 2009: 4) as a sudden deterioration in the financial markets of a particular country or group of countries due to the failure of the local banking system to perform its basic functions. It is also known as a sudden decline in the price of a type of asset, including the physical capital used in the production process. , Or financial assets such as stocks. If these assets suddenly collapse, this will lead to a state of bankruptcy, which is a collapse in the value of the financial institutions that own them (Rotheli, 2010: 287), and (ALDamee, 2021: 325). The financial crisis is defined as the bank’s inability to fulfill its obligations to customers. And the owners, which makes it difficult as a result of low liquidity ratios.

2- Types of financial crises

There are many financial crises that can be classified as follows:

A) Banking crises:

It refers to the situation in which a bank becomes insolvent due to a lack of liquidity due to its inability to extend debt maturities or meet the requirements for sudden withdrawal of demand deposits. Banking crises are therefore processes of withdrawal of actual or potential bank deposits, and these crises tend to last longer than financial crises and have a more severe impact on the volume of economic activity (IMF 2002:4-7), which in turn leads to a loss of confidence in banks as an activity. economic. They reduced the internal convertibility of debt, and then the so-called banking liquidity crisis occurred (Gupta, 2000:15).

B) debt crisis

It is a situation in which a country is unable to pay its internal and external debts. The external debt crisis is linked to the non-payment of debts to the public and private sectors and occurs when the state finds itself in a position where it is unable to pay its accumulated external debts, and then leads to an economic imbalance and fluctuations in prices. assets or the foreign exchange rate, while the internal debt crisis is mainly due to the state’s inability to fulfill its domestic financial obligations (Abu Shteiwi, 2022: 18).

3- Indicators for predicting the financial crisis

There are many indicators that can predict a financial crisis, including:

A) Asset quality

This indicator is considered one of the most important and prominent indicators for the bank’s management. The deterioration of the quality of banking assets due to misuse of management in dealing with loans and the lending system may lead to imbalances and disasters in the financial position in the future and may require writing off part or all of the loans. The process of classifying the quality of assets shows the size Expected risks related to the lending process, owned real estate, investment portfolios, and the bank’s off-budget activities, as classifying the quality of assets gives management the ability to identify, measure and monitor risks, accompanied by taking the adequacy of debt allocations into consideration, as well as measuring the risks affecting investment values, which are represented by operational risks, strategic risks, and risks. Market, reputation, etc. (Abata, 2014: 39). The classification of assets by type reflects the extent of future and current risks of the investment portfolio, owned real estate, and other off-balance sheet activities, as well as The bank's ability to monitor, identify and control risks and takes into account the adequacy of debt allocations and risks that could affect the value of investments, such as market risks, reputation, operational risks and the extent of compliance with regulations. The quality ratio of assets is measured by several equations, the most important of which is:

*The ratio of profitable assets to total deposits: Deposits are one of the most important and most important sources of financing that the bank relies on in carrying out its activities. This ratio shows how bank deposits are used in the field of profitable assets (Al-Amiri, 2013: 88) as follows.

Asset quality = total assets / total deposits1

This percentage is one of the indicators that was adopted in the practical aspect of the research

The third section: the applied aspect

It includes two main points:

First/Description and analysis of data: In this section, the research data will be described and analyzed according to the research variables as follows:

1- The independent variable: Box-Jenkins methodology, which is represented by the four stages

(Recognition phase, estimation phase, testing phase, prediction phase)

2- The dependent variable: the financial crisis, which is represented by the financial crisis index as follows:

Asset quality index: It is represented by the percentage of asset quality shown by equation (1). Table (1) shows the percentage of asset quality for the banks in the research sample, which consists of 4 banks listed on the Iraqi Stock Exchange for a period of 12 years for the period from (1/1/2011) to (12/31/2022), as follows:

Table (1) Asset quality ratio of the banks in the research sample for the period (2011 - 2022) (%)

	The banks	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
1	Baghdad Bank	125.15	124.26	126.64	122.51	172.67	142.48	146.58	142.39	141.35	132.40	133.03	131.68
2	Middle East Bank	130.21	132.99	140.28	190.74	203.53	201.16	231.71	182.85	235.67	247.50	230.75	314.59
3	Iraqi Investment Bank	175.04	196.62	183.76	217.59	212.13	227.50	234.18	254.36	251.14	212.36	264.62	211.41
4	United Investment Bank	219.06	286.35	215.97	320.55	253.86	379.38	499.88	402.13	870.26	459.31	280.60	504.69

Source: Prepared by the researcher based on the annual financial reports of the banks in the research sample for the period (2011 - 2022)

Second: Testing and analyzing research hypotheses

In this section, the research hypotheses are tested and analyzed by identifying the following points that clarify whether or not the hypotheses are accepted regarding the possibility or impossibility of predicting the financial crisis using the Box-Jenkins methodology according to the following steps:

The first step - knowing the stability of the data based on the arithmetic mean by plotting the true values of the time series studied to identify the general behavior and the absence of high fluctuations.

The second step is to extract the Z value to determine the significance when the p-value is less than 5%. The goal is to use the Box-Jenkins methodology and test the appropriate model based on the values of the AIC, SC, and HQ criteria for the autoregressive model and moving averages (ARMA(1,0, 0))

Step Three- Estimate model parameters

Step Four - Test the accuracy of the model in predicting the financial crisis by extracting the resulting error values for the autocorrelation values ACF and partial autocorrelation PACF.

Step Five - Future prediction of the financial crisis for the next three years (2023, 2024, 2025)

Second: Testing the sub-hypothesis

Null hypothesis: H_0 : It is not possible to predict the financial crisis according to the asset quality index using the Box-Jenkins methodology.

Alternative hypothesis H_1 : The possibility of predicting the financial crisis according to the asset quality index using the Box-Jenkins methodology.

Here, the above hypothesis is tested through the five steps mentioned previously:

Figure (1) shows the real values of the time series studied with the aim of knowing its general behavior, and the following figure shows the series plot for the asset quality variable, through which it is clear that there is stability in it with respect to the arithmetic mean. There are also no high fluctuations in it depending on time for the Bank of Baghdad and the Bank, except for the year 2019 for the United Investment Bank. The year 2016 is for the National Bank of Iraq, and it is clear that there is an increase in the arithmetic mean, and there are also no high fluctuations in it depending on time for the Bank (Middle East, Iraqi Investment Bank).

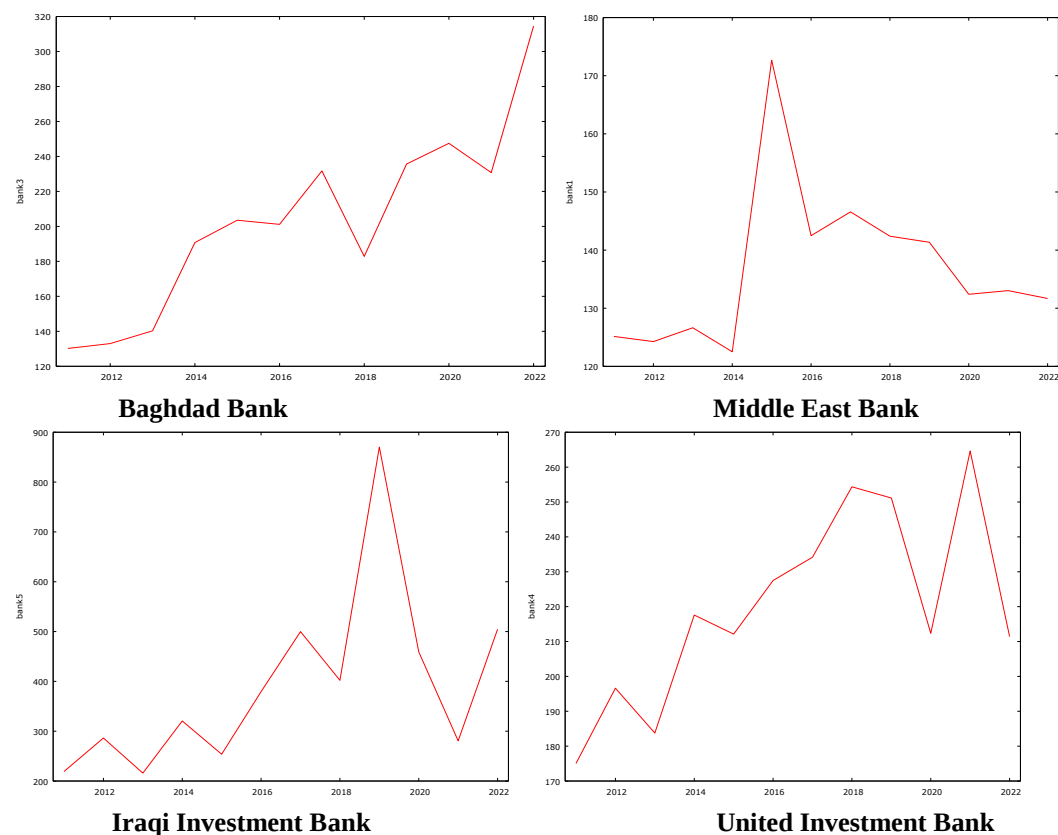


Figure (1) plotting the real values of banks' asset quality

Source prepared by the researcher: based on the statistical program: Gretl

After the data stabilization process, it will be done here:

Using the Box-Jenkins method to determine the appropriate model for time series data, estimate its parameters, test its accuracy, and then use it for the purpose of future forecasting.

The appropriate model for bank data is the autoregressive model and the ARMA(1,0,0) moving average, based on the values of the AIC, SC, and HQ criteria, whose values were the lowest among a group of models. After determining the appropriate model, its parameters were estimated and then tested as a second step in determining Appropriate model. Then the third step begins to estimate the model parameters, which is shown in Table (25).

As for the Bank of Baghdad, it is noted that the value of the model parameter was (0.99) with a standard error of (0.013), and the value of its Z test was equal to (73.4378), which is a value with moral significance because its p-value is equal to 00.00, which is less than the specified significance level. 5%.

As for the Middle East Bank, it notes that the value of the model parameter was (-0.65) with a standard error of (0.252), and its Z-test value was equal to (-2.5930), which is a value with moral significance because its p-value is equal to 00.00, which is less than the level The specified significance is 5%.

As for the Iraqi Investment Bank, it notes that the value of the model parameter was (-0.75) with a standard error of (0.213), and its Z-test value was equal to (-3.5327), which is a value with moral significance because its p-value is equal to 00.00, which is less than the level The specified significance is 5%.

As for United Investment Bank, we note that the value of the model parameter was (0.86) with a standard error of (0.122), and the value of its Z test was equal to (7.0005), which is a value with moral significance because its p-value is equal to 00.00, which is less than the specified significance level. 5%.

Table (2) Estimating the parameters of the model specified for the data of the banks in the research sample

رمز المصرف	Coefficient	Std. Error	Z	p-value	Akaike criterion	Hannan-Quinn	SC criterion
Baghdad Bank	0.990323	0.0134852	73.4378	<0.00001	111.3227	110.9637	112.2925

Middle East	-0.655289	0.252714	-2.5930	<0.00001	109.2373	108.5734	109.8424
Iraqi Investment	-0.752966	0.213139	-3.5327	<0.00001	103.0473	102.5457	103.8431
United Investment	0.860399	0.122905	7.0005	<0.00001	167.9637	167.6047	168.9335

Source prepared by the researcher: based on the statistical program: Gretl

After estimating the model parameters, its accuracy in prediction is now tested by relying on the values of the resulting errors shown in Tables (3, 4, 5, 6) for the banks in the research sample, and that all values are within the limits of random errors, which indicates the suitability of the proposed model and its accuracy in Use to obtain predictive values for the banks in the research sample

Table (3) ACF and PACF values for the model residuals for the Bank of Baghdad ARMA(1,0,0)

Residual autocorrelation function				
LAG	ACF	PACF	Q-stat. [p-value]	
1	-0.1249	-0.1249	0.2382	[0.626]
2	0.0327	0.0173	0.2561	[0.880]
3	-0.0796	-0.0747	0.3745	[0.945]
4	0.3314	0.3190	2.6811	[0.613]
5	-0.2570	-0.2084	4.2664	[0.512]
6	-0.0048	-0.0603	4.2670	[0.641]
7	-0.0976	-0.0697	4.5874	[0.710]
8	-0.0476	-0.2132	4.6826	[0.791]

Source prepared by the researcher: based on the statistical program: Gretl

Table (4) shows the values of the autocorrelation ACF and the partial autocorrelation PACF for the resulting errors for the Middle East Bank as follows:

Table (4) ACF and PACF values for the model residuals for the Middle East Bank ARMA(1,0,0)

Residual autocorrelation function				
LAG	ACF	PACF	Q-stat. [p-value]	
1	-0.4758	-0.4758	3.0189	[0.082]
2	-0.0407	-0.3453	3.0438	[0.218]
3	0.3645	0.2555	5.3210	[0.150]
4	-0.4973	-0.2857	10.2665	[0.036]
5	0.2805	-0.0076	12.1550	[0.033]
6	-0.0920	-0.2109	12.4092	[0.053]
7	-0.1842	-0.1247	13.7658	[0.056]
8	0.1537	-0.3045	15.1826	[0.056]

Source prepared by the researcher: based on the statistical program: Gretl

Table (5) shows the values of the autocorrelation ACF and the partial autocorrelation PACF for the resulting errors of the Iraqi Investment Bank and my agencies:

Table (5) ACF and PACF values for the model residuals for the Iraqi Investment Bank ARMA(1,0,0)

Residual autocorrelation function				
LAG	ACF	PACF	Q-stat. [p-value]	
1	-0.2241	-0.2241	0.7184	[0.397]
2	0.1694	0.1254	1.1741	[0.556]
3	0.0308	0.0986	1.1911	[0.755]
4	-0.0270	-0.0249	1.2061	[0.877]
5	-0.1611	-0.2082	1.8246	[0.873]
6	-0.1128	-0.2048	2.1884	[0.902]
7	0.0703	0.0805	2.3651	[0.937]
8	-0.2511	-0.1591	5.3709	[0.717]

Source prepared by the researcher: based on the statistical program: Gretl

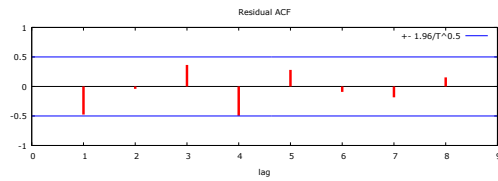
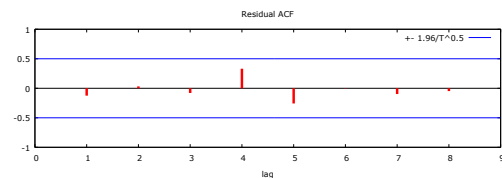
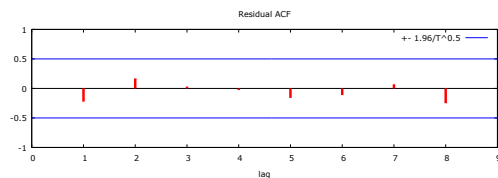
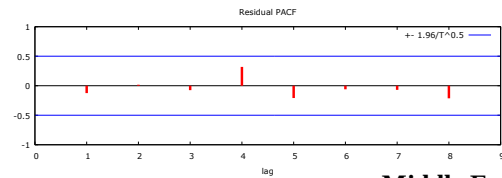
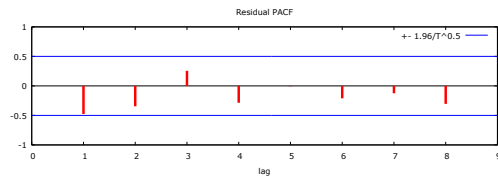
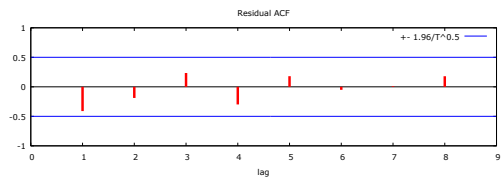
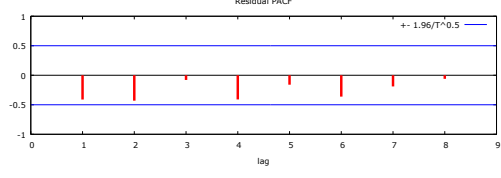
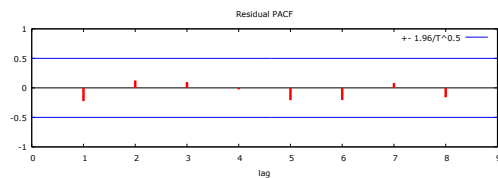
Table (6) shows the values of the autocorrelation ACF and the partial autocorrelation PACF for the resulting errors for the United Investment Bank and my agencies:

Table (6) ACF and PACF values for the model residuals for United Investment Bank ARMA(1,0)

Residual autocorrelation function				
LAG	ACF	PACF	Q-stat. [p-value]	
1	-0.4112	-0.4112	2.5829	[0.108]
2	-0.1885	-0.4304	3.1800	[0.204]
3	0.2342	-0.0794	4.2037	[0.240]
4	-0.2987	-0.4096	6.0772	[0.193]
5	0.1801	-0.1599	6.8556	[0.232]
6	-0.0509	-0.3616	6.9281	[0.328]
7	0.0114	-0.1891	6.9325	[0.436]
8	0.1793	-0.0601	8.2831	[0.406]

Source prepared by the researcher: based on the statistical program: Gretl

Figure (2) shows the values of ACF and PACF, from which it is clear that all values are within the limits of random errors. This indicates the suitability of the proposed model and its suitability for use to obtain predictive values for banks:

**Baghdad Bank****Middle East****United Investment****Iraqi Investment**

United Investment Iraqi Investment

Figure (2) ACF and PACF values for the remainder of the bank data model in the research sample

Source prepared by the researcher: based on the statistical program: Gretl

As a final and final step, the previous model was used to obtain future predictive values for the next three years, which are shown in Table (7) as follows:

Table (7) Future predictive values of asset quality for the banks in the research sample

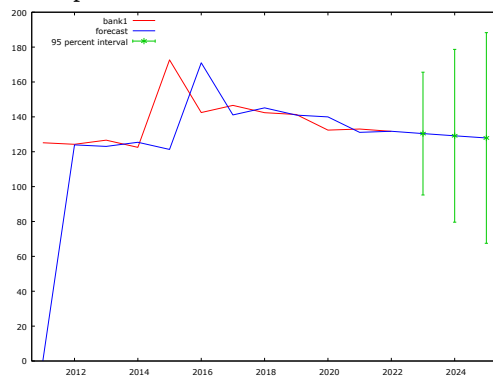
For 95% confidence intervals, $z(0.025) = 1.96$

The Bank	Obs	Prediction	std. error	95% interval
Baghdad Bank	2023	130.406	17.9622	(95.2005, 165.611)
	2024	129.144	25.2798	(79.5964, 178.691)
	2025	127.894	30.8123	(67.5031, 188.285)

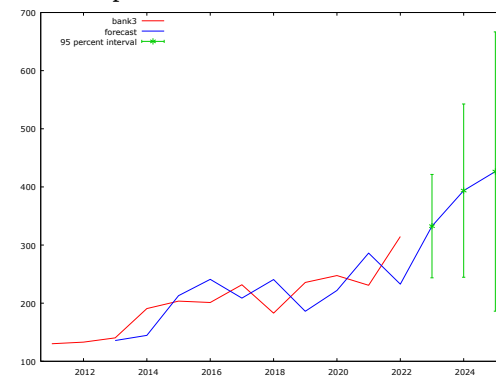
Middle East	2023	332.514	45.3709	(243.589, 421.440)
	2024	393.633	76.0318	(244.613, 542.652)
	2025	426.446	122.566	(186.222, 666.671)
Iraqi Investment	2023	251.475	21.0136	(210.289, 292.661)
	2024	221.308	21.6453	(178.884, 263.731)
	2025	244.023	27.5880	(189.951, 298.094)
United Investment	2023	434.235	212.026	(18.6716, 849.798)
	2024	373.615	279.705	(-174.596, 921.826)
	2025	321.459	320.735	(-307.171, 950.088)

Source prepared by the researcher: based on the statistical program: Gretl

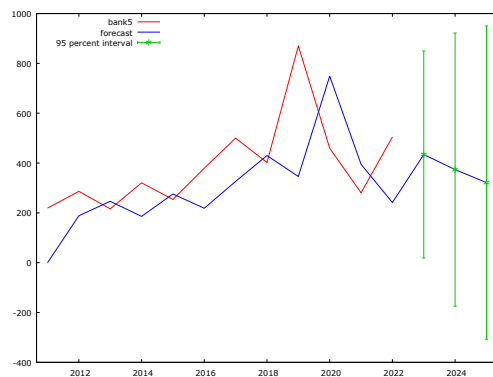
Figure (3) shows the true values of banks' liquidity and the future predictive values for the next three years, in addition to the confidence limits. As is clear from the table and figure below, the Box-Jenkins model predicts the presence of a future crisis in all the banks in the research sample, as the predictive values decrease over time, but slightly. With the exception of the Middle East Bank and the Iraqi Investment Bank, it is clear that the Box-Jenkins model predicts that there will be no future crisis in these banks, as the predictive values increase over time. Slightly, with the exception of the Middle East Bank and the Iraqi Investment Bank, it is clear that the Box-Jenkins model predicts that there will be no future crisis for these banks, as the predictive values increase over time.



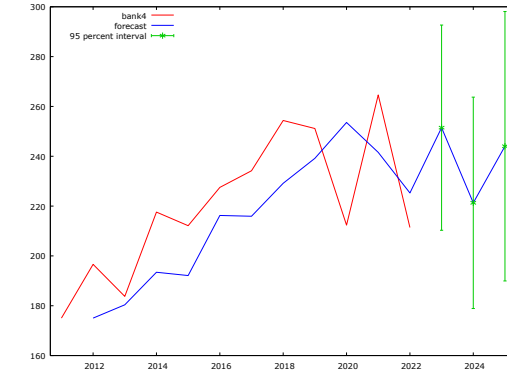
Baghdad Bank



Middle East



United Investment



Iraqi Investment

Figure (3) Actual and predictive values of asset quality for the banks in the research sample

Table (8) Summary of financial crisis forecasting using the Box-Jenkins methodology

Axes	The banks	Predicting the crisis based on the Box-Jenkins method
1	Baghdad Bank	There is a crisis
2	Middle East	There is no crisis
3	United Investment	There is a crisis
4	Iraqi Investment	There is no crisis

According to the test of the asset quality index as an early warning indicator of the financial crisis and using the Box-Jenkins methodology, it can be observed that there is stability in some banks and an increase in others in relation to the arithmetic mean. There are also no high fluctuations depending on time and for all banks in the research sample except in specific years, which confirms the acceptance of the hypothesis. Alternative H1 for the first sub-hypothesis on the possibility of predicting the financial crisis as an indicator of the financial crisis, which showed that the Box-Jenkins model predicts the presence of a future crisis in all banks in the research sample, as the predictive values decrease over time, but slightly, with the exception of the Middle East Bank and the Iraqi Investment Bank. It is clear that the model Box-Jenkins predicts that there will be no future crisis for these banks, as the predictive values increase over time.

Conclusions

- 1- There is a possibility to predict the financial crisis using the Box-Jenkins methodology for all banks in the research sample.
- 2- The Box-Jenkins methodology is one of the most important early warning indicators for predicting banking crises from all financial, technical and administrative aspects to identify areas of strength to enhance and areas of weakness to develop solutions and treatments for them.
- 3- The best model of the Box-Jenkins models is the (0,0,1) ARMA model for all banks in the study sample, which was used to draw conclusions and predict the financial crisis on its basis.
- 4- The absence of a future crisis based on the Box-Jenkins method for the Middle East Bank and the Iraqi Investment Bank, and the presence of a crisis for the rest of the banks in the research sample.
- 5- A package of measures can be used to avoid falling into a future crisis or mitigate its effects based on predictive values, as the prediction of these crises was slight in some banks and can be remedied.

Recommendations

- 1- It is necessary to conduct other studies to predict financial crises, such as the use of neural networks, multivariate time series models (Altman, Kadi, Sherrod) and their application in the Iraqi Stock Exchange.
- 2- Verifying mutual relationships by studying the variables that control financial distress and building programmed cognitive systems that help in decision-making.
- 3- Iraqi banks listed on the Iraqi Stock Exchange must adhere to the regulations and laws issued by the Central Bank, which are represented by standard ratios, in order to avoid banking crises and limit the occurrence of banking risks in the future.
- 4- The need for researchers to pay attention to other studies to predict financial crises, such as the use of neural networks, multivariate time series models (Altman, Kadi, Sherrod model), and to conduct a comparison between the prediction model of the current study with the models of the mentioned studies and find out the points of similarity and difference between them.

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