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Modeling the Factors Influencing the Occurrence of Economic Crises in Sudan Using Logistic Regression (2011–2023)

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Abstract:

This study aimed to determine the relationship between political changes, internal conflicts, inflation, and foreign investment growth with the occurrence of economic crises. The impact of political and economic variables on economic crises in Sudan was analyzed using an appropriate statistical model. Logistic regression was employed to examine the effects of these variables. The results indicated that political changes and internal conflicts significantly influence the likelihood of economic crises. Additionally, an increase in foreign investment positively affects the probability of economic crises, while inflation showed no significant impact on the occurrence of economic crises in Sudan. Furthermore, logistic regression demonstrated its efficiency in analyzing the factors influencing economic crises by accurately identifying the most impactful variables.

The study recommended enhancing political stability and resolving internal conflicts. It also suggested that the government should adopt effective policies to control inflation and regulate foreign direct investment. Moreover, the study emphasized the importance of developing advanced analytical models that integrate time series models with logistic regression for economic crisis analysis. Additionally, it recommended utilizing logistic regression in economic policies as a predictive tool to assist policymakers in taking preventive measures against potential crises.

***Keywords*: Statistical Modeling, Logistic Regression, Political Changes, Internal Conflicts**

1. Introduction

Most developing countries suffer from multiple economic crises, often linked to political and security challenges, as well as economic factors such as high inflation rates.

Sudan, as a country with a long history of internal conflicts, political changes, and economic fluctuations, represents an important case study for understanding these relationships and their impact on the occurrence of economic crises.

This paper aims to explore the effect of internal conflicts, political changes, and key economic indicators on the occurrence of economic crises using logistic regression modeling. This will provide a foundation for understanding how these factors influence the likelihood of economic crises.

1.1 Problem Statement

Although there are many studies on the causes of economic crises, the use of predictive statistical models—especially logistic regression—is still underutilized in analyzing economic crises in Sudan.

Thus, the central research question is:

Can logistic regression be used to predict the occurrence of economic crises? And what is the extent of the influence of independent variables on that?

From this central question, the following sub-questions arise:

Do internal conflicts affect the likelihood of economic crises in Sudan?

Do political changes affect the likelihood of economic crises in Sudan?

What is the nature of the relationship between high inflation rates and the likelihood of economic crises in Sudan?

What is the nature of the relationship between increased foreign direct investment and the likelihood of economic crises in Sudan?

Is logistic regression a suitable model for predicting future economic crises in Sudan?

1.2 Hypotheses of the Study

There is a statistically significant relationship between internal conflicts and the likelihood of economic crises in Sudan.

There is a statistically significant relationship between political changes and the likelihood of economic crises in Sudan.

There is a statistically significant relationship between rising inflation rates and the likelihood of economic crises in Sudan.

There is a statistically significant relationship between increased foreign direct investment and the likelihood of economic crises in Sudan.

Logistic regression can be used to predict the occurrence of future economic crises in Sudan.

1.3 Objectives of the Study

To identify the nature of the relationship between internal conflicts and the likelihood of economic crises in Sudan.

To identify the nature of the relationship between political changes and the likelihood of economic crises in Sudan.

To identify the nature of the relationship between inflation rates and the likelihood of economic crises in Sudan.

To identify the nature of the relationship between foreign direct investment and the likelihood of economic crises in Sudan.

To apply the logistic regression model to analyze the relationship between the independent variables and the likelihood of economic crises, and to test the model's predictive accuracy.

1.4 Significance of the Study

1.4.1 Theoretical Significance: This study may contribute to bridging the research gap related to the use of statistical models in analyzing economic crises in Sudan. It also highlights the importance of logistic regression as a powerful tool for predicting and analyzing the factors influencing economic crises.

1.4.2 Practical Significance: The study may help researchers understand the role of statistical methods (like logistic regression) in modeling and interpreting the relationships between various economic variables.

1.5 Methodology

The study adopts the descriptive-analytical approach.

1.6 Research Tools

Secondary Sources: Including academic books, articles, theses, journals, official reports, and both printed and electronic publications related to the research topic.

1.7 Study Limits

1.7.1 Spatial Limit: The Republic of Sudan

1.7.2 Temporal Limit: From 2011 to 2023

1.8 Terminology

1.8.1 Statistical Modeling: "The process of using statistical techniques to build models that explain the relationships between variables and help in predicting outcomes." (Montgomery, 2021)

1.8.2 Logistic Regression: "A statistical technique used to model the relationship between a binary dependent variable (e.g., success/failure) and a set of continuous or categorical independent variables. It relies on a logistic function to transform outputs into probabilities ranging from 0 to 1." (Hosmer & Sturdivant, 2013)

1.8.3 Political Changes: "Transitions in governance systems or public policies that may significantly impact the national economy." (Acemoglu & Robinson, 2012)

1.8.4 Internal Conflicts: "Refers to armed conflicts and unrest that affect the security and stability within a country and are a major factor in studies of economic development." (Collier & Hoeffler, 2004)

2. Theoretical Framework & Literature Review

2.1 Concept of Statistical Modeling

Statistical modeling involves building mathematical models using statistical techniques to analyze relationships between variables, aiming to understand the phenomenon under study or predict its behavior. It describes the relationship between independent and dependent variables and helps in decision-making based on data (El-Baz, 2016).

2.1.1 Objectives of Statistical Modeling

Describe relationships and test hypotheses (Zidan, 2017)

Forecast future phenomena like economic performance or policy outcomes (Hassan, 2020)

Identify the most influential variables to focus on critical factors in analysis.

2.1.2 Importance of Statistical Modeling in Economic Problems:

It is a powerful tool to analyze socio-economic phenomena, such as the impact of internal conflicts and political changes on the economy. Logistic regression can be used to model the relationship between armed conflicts and unemployment levels (Murad, 2019).

2.2 Logistic Regression

A widely used statistical model for analyzing relationships between a binary dependent variable (e.g., Yes/No) and independent variables (quantitative or qualitative). It estimates the probability of an event based on those variables (El-Baz, 2016).

Key Assumptions

2.2.1 Independence of Variables: Independent variables should not be highly correlated (Murad, 2019)

Log-linear Relationship: Between the dependent variable and the log-odds.

No Multicollinearity: No strong linear relationship among independent variables (Zidan, 2017)

2.2.2 Binary Dependent Variable: The outcome must be binary.

2.2.3 Importance of Logistic Regression

Interpretation: It analyzes the influence of political and economic variables on crisis occurrence

Flexibility: Can handle both continuous and categorical predictors (Murad, 2019)

Prediction: Useful for predicting the probability of future economic crises

2.3 Economic Crisis

A situation of sudden economic imbalance, causing contraction of economic activity, rising unemployment, reduced productivity, and financial market instability, ultimately affecting individual welfare and macroeconomic stability.

2.4 Political Changes

"Transformations in the structure or political system of a country, which may result from constitutional reforms, coups, or revolutions. These significantly affect state stability and economic and social development." (Huntington, 1991)

2.5 Internal Conflicts

Conflicts between domestic parties—political, ethnic, or religious groups—seeking political, economic, or social gains, often accompanied by violence, threatening political and economic stability. (UNDP, 2024)

2.6 Economic Crises in Sudan (2011–2023)

2.6.1 Post-South Sudan Separation Crisis (2011–2014)

Sudan lost around 75% of its oil production, its main source of government revenue and foreign currency, leading to a massive fiscal deficit and debt dependence. Foreign exchange shortages caused inflation to exceed 40% in some years. (World Bank, 2014)

2.6.2 Impact of Economic Sanctions (2011–2017)

US sanctions restricted foreign investment and the import of essential goods and equipment. The agricultural sector declined due to a lack of financing and poor infrastructure. (IMF, 2016)

2.6.3 Crisis and Political Unrest (2018–2019)

Inflation exceeded 70% in 2018. Economic collapse, bread and fuel shortages sparked protests, which led to regime change in 2019.

2.6.4 Economic Reforms Under IMF Pressure (2020–2021)

The transitional government launched reforms: fuel and electricity subsidies were lifted, triggering protests. In 2021, it unified the exchange rate, which led to further devaluation and inflation soaring over 400%.

2.6.5 Armed Conflict and Crisis (2023 Onward)

The war between the army and the Rapid Support Forces caused a humanitarian and economic crisis. Most economic activity halted, trade was disrupted, banks closed, and the financial system collapsed, worsening liquidity access.

2.7 Inflation

A continuous and sustained increase in the general price level of goods and services over time, reducing the purchasing power of money. Measured by indices like CPI or PPI, inflation can result from high demand, rising production costs, or expansionary monetary policies.

2.8 Foreign Direct Investment (FDI)

FDI refers to investments by foreign entities into domestic projects, either by creating new ventures or acquiring stakes in existing companies. It typically involves active participation in management and production. (UNCTAD, 2024)

2.9 Previous Studies

2.9.1. Sahar Hamad Mehran's Study (2017)

Title: Predicting the Stages of the Financial Crisis Impact on Bank Performance Using Logistic Regression: An Analytical Study Applied to the Banking Sector in the GCC Countries

This study aimed to analyze the impact of the global financial crisis on the performance of banks in the GCC countries using the logistic regression model. Three models were built to represent the different stages of the crisis. The study concluded that the logistic model for the first stage could predict banks' entry into crisis with a classification accuracy of 80.6%.

2.9.2. Al-Sharabi, Mohamed Younes' Study (2018)

Title: Using Logistic Regression to Predict Bank Default: An Analytical Study

This study aimed to use logistic regression to predict bank default in a sample of Emirati banks by analyzing a set of financial ratios and relevant indicators. The study concluded that logistic regression could be efficiently used to predict bank default.

2.9.3. Mohamed et al. (2020)

Title: Using Probabilistic Models to Study Financial Crises in Africa: An Analytical Study Using Logistic Regression to Predict Bank Default

This study aimed to apply probabilistic models to analyze financial crises in African countries. The researchers relied on probability estimation techniques (such as Maximum Likelihood Estimation) to identify economic and financial factors contributing to the occurrence of crises. The results showed that falling oil prices and rising inflation rates were key indicators increasing the likelihood of financial crises in the targeted countries. The study also highlighted the importance of using probabilistic models to forecast crises to adopt proactive policies to mitigate their effects.

2.9.4. Al-Khubairi's Study (2021)

Title: Analyzing the Impact of Exchange Rates on Emerging Markets Using Dynamic Models

This study aimed to examine the effect of exchange rate fluctuations on emerging markets using dynamic models and time series analysis. Multiple dynamic models were used to identify the relationship between exchange rate volatility and economic growth in these markets. The results indicate that exchange rate fluctuations are a key indicator of the stability of emerging markets and that the dynamic model provides a useful framework for understanding the temporal and reciprocal effects of these fluctuations on economic growth.

2.9.5 Commentary on Previous Studies

Sahar Hamad Mehran's Study (2017):

The current study agrees with the previous one in the use of logistic regression for prediction but differs in its subject matter. The previous study focused on predicting the stages of the financial crisis' impact on bank performance, while the current study models the factors influencing the occurrence of economic crises in Sudan using logistic regression.

Al-Sharabi, Mohamed Younes' Study (2018):

The current study agrees with the previous one in the use of logistic regression for prediction but differs in its topic. The previous study focused on using logistic regression to predict bank default, while the current study models the factors affecting the occurrence of economic crises in Sudan using logistic regression.

Mohamed et al. (2020):

The current study aligns with the previous one in using logistic regression for crisis prediction but differs in its focus. The previous study applied probabilistic models to analyze financial crises in Africa and used logistic regression to predict bank defaults, whereas the current study focuses on modeling the factors influencing economic crises in Sudan using logistic regression**.**

Al-Khubairi's Study (2021):

The current study agrees with the previous one in the use of dynamic models to analyze crises but differs in focus. The previous study analyzed the impact of exchange rate fluctuations on emerging markets using dynamic models, while the current study models the factors affecting economic crises in Sudan using logistic regression.

It is noteworthy that most of the previous studies align with the current study in their use of logistic regression to predict crises yet differ in their fields of application and the types of crises addressed.

3. Methodological Framework and Data Analysis

The main objective of this study is to construct a statistical model to identify the impact of political and economic factors on the occurrence of economic crises in Sudan during the period from 2011 to 2023. The data were adjusted and converted into quarterly data to improve the number of observations and the accuracy of analysis. The study adopted the logistic regression model to describe the relationship between the dependent variable (economic crisis) and the independent variables (political changes, internal conflicts, inflation, foreign direct investment).

Description of Model Variables

3.1 First: The Dependent Variable (Economic Crisis)

The economic crisis variable represents the dependent variable in the study. It was described using the economic growth rate for each year under study. This variable represents the economic condition for the corresponding year and is coded as follows:

1 if the economic growth rate is negative (indicating an economic crisis occurred),

0 if the economic growth rate is positive (indicating no crisis occurred).

Table 1: Economic Growth Rate

Year	Economic Growth Rate	Economic Crisis Occurrence
2011	-3.2	1
2012	-17	1
2013	2	0
2014	4.7	0
2015	1.9	0
2016	3.5	0
2017	0.7	0
2018	-2.7	1
2019	-2.2	1
2020	-3.6	1
2021	-1.9	1
2022	-1	1
2023	-20.1	1

Source: World Bank Group – 2025 https://data.albankaldawli.org/indicator/NY.GDP.MKTP

3.2 Second: Independent Variables:

3.2.1- Political Changes:

This variable represents the significant political events that occurred during the year. The year is coded as (1) if a significant political event took place (such as elections, major government changes, coups, or major political crises), and as (0) if no notable political change occurred.

Table 2: Significant Political Events

Year	Significant Political Events	Political Change
2011	Separation of South Sudan and its impact on the political landscape	1
2012	No significant political events	0
2013	Widespread protests due to fuel subsidy cuts	1
2014	Relative stability with no major political changes	0
2015	No significant political changes	0
2016	No major political changes	0
2017	Relative political stability despite internal challenges	0
2018	Outbreak of popular protests leading to political tensions	1
2019	Fall of the ruling regime and formation of the transitional sovereign council	1
2020	Continuation of the transitional phase without major political change	0
2021	Political change with the removal of the transitional government in October 2021	1
2022	Continuation of the transitional phase with no major political changes	0
2023	Outbreak of conflict between the army and Rapid Support Forces and escalating political tensions	1

Source: Researcher's data based on news reports – 2024

3.2.2- Internal Conflicts

The "Internal Conflicts" variable refers to the level of internal disturbances and conflicts occurring within the country, which affect its political, economic, and social stability. This variable is used as an indicator of the negative effects of conflicts on the economy and society. The internal conflicts variable is measured by the number of internally displaced persons (IDPs), where the number of people forced to leave their homes due to internal conflicts is considered a direct indicator of the severity of these conflicts.

3.2.3- Inflation

Inflation is the continuous rise in the general price level of goods and services in the economy over a specified period, leading to a decrease in the purchasing power of money. Inflation is usually measured as an annual percentage and serves as an important indicator of changes in supply and demand in the economy.

3.2.4- Foreign Direct Investment (FDI)

Foreign direct investment is an important factor in stimulating the national economy, especially in light of the economic challenges the country faces, such as economic sanctions, poor infrastructure, and political instability. The Sudanese government aims to boost economic growth, create new jobs, increase foreign exchange earnings, and transfer technology and knowledge from developed countries through encouraging foreign investment (World Bank, 2024).

Table 3: Quantitative variables

Year	Internal Conflicts (Number of IDPs)	Inflation (%)	Foreign Direct Investment (USD)
2011	19,000	18.10	3.15
2012	84,000	35.56	6.14
2013	284,000	36.52	3.92
2014	187,000	36.91	2.53
2015	8,300	16.91	3.34
2016	123,000	17.75	2.50
2017	54,000	32.35	2.58
2018	121,000	63.29	3.51
2019	272,000	150.99	2.55
2020	454,000	163.26	2.65
2021	109,000	359.09	1.53
2022	105,000	238.81	1.11
2023	58,000	232.66	1.32

Source: World Bank Group - 2025 https://data.albankaldawli.org/indicator/NY.GDP.MKTP

4. Analysis of Study Data

4.1 First: Descriptive Statistics of Quantitative Study Variables

Table 4: Descriptive Statistics

Variable	Mean	Standard Deviation	Maximum	Minimum
Inflation	106.79	103.92	359.09	16.91
Internal Conflicts	150,973.5	106,849.4	454,000	8,300
Foreign Direct Investment	2.83	1.35	6.35	0.89

Source: Researcher's data from study data (EViews) – 2025

The table above shows the descriptive statistics of the quantitative variables in the study. From this, we can observe the following:

The mean of the "Foreign Direct Investment" variable is 2.83 and its standard deviation is 1.35, while the mean of the "Internal Conflicts" variable is 150,973.5 and its standard deviation is 106,849.4. Similarly, the mean of the "Inflation" variable is 106.79% and its standard deviation is 103.92%.

The highest value of the "Foreign Direct Investment" variable is 6.35, while its lowest value is 0.89. Similarly, the highest value of the "Internal Conflicts" variable is 454,000, while its lowest value is 8,300. Also, the highest value of the "Inflation" variable is 359.09% and its lowest value is 16.91%.

The total number of observations is 52, representing the study period from 2011 to 2023, with quarterly data.

4.2 Second: Testing the Stationarity of Time Series: Before estimating the model, a unit root test was conducted on the quantitative variables using the Augmented Dickey-Fuller (ADF) test as follows:

Table 5: Testing the Stationarity of Time Series

Variable	Level of Data	First Difference	Second Difference
Inflation	-1.72 (0.42)	-1.33 (0.61)	-8.06 **(0.00)
Internal Conflicts	-3.29 ***(0.02)		
Foreign Direct Investment	-2.75 (0.07)	-4.22 ***(0.00)	

Source: Researcher's data from study data (EViews) – 2025

From the table above, we can observe the following:

For the inflation variable, the series became stationary at the second difference with a test value of -8.06 and a significance level below 0.05.

For the internal conflict's variable, the series became stationary at the level of the data with a test value of -3.29 and a significance level below 0.05.

For the foreign direct investment variable, the series became stationary at the first difference with a test value of -4.22 and a significance level below 0.05.

It is noteworthy that the stationarity test was conducted only on the quantitative independent variables included in the model.

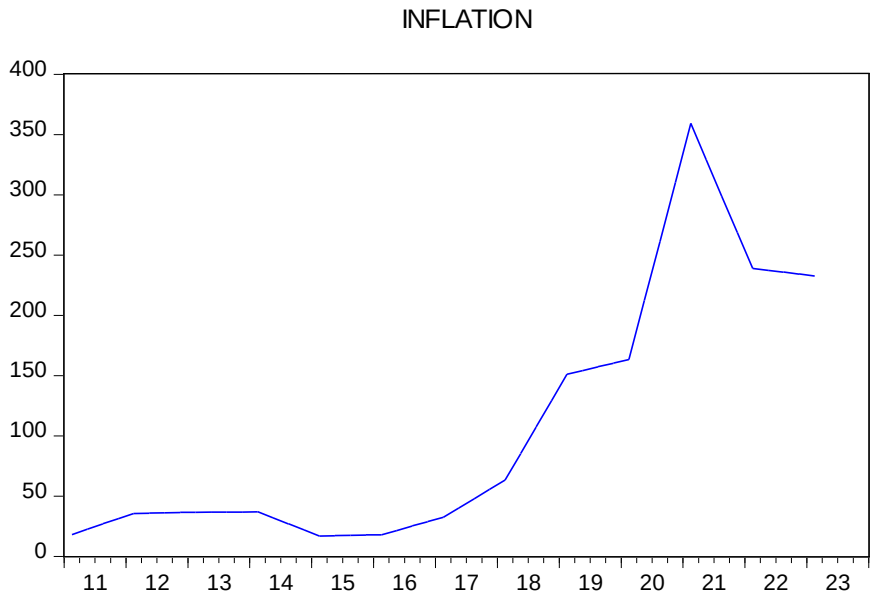

Figure 1: illustrate the inflation variable before taking the second difference.

Source: Researcher's data from study data (EViews) – 2025

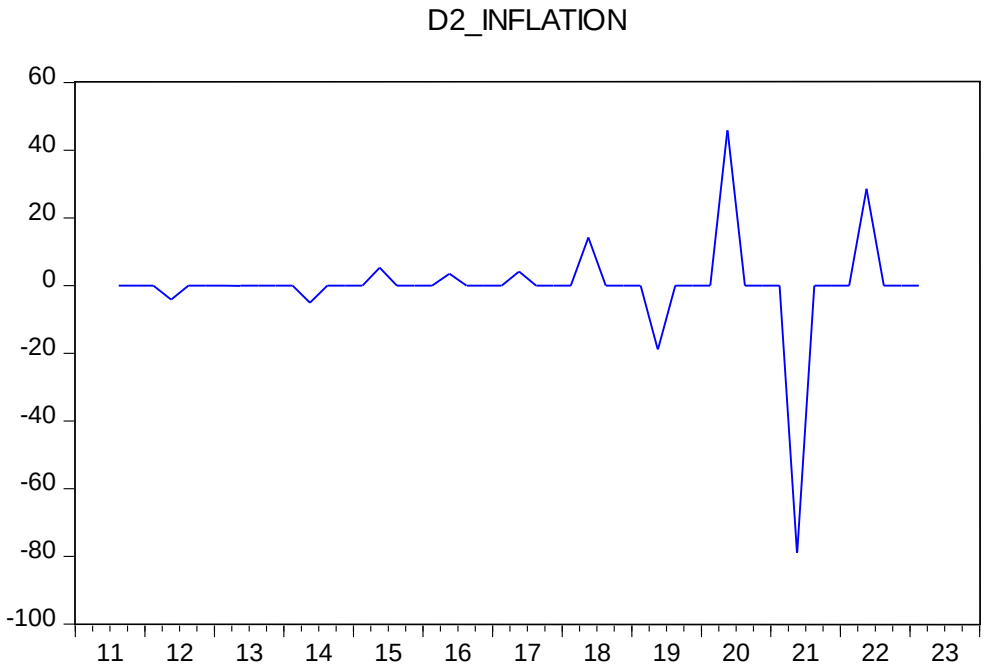

Figure 2: illustrates the inflation variable after taking the second difference.

Source: Researcher's data from study data (EViews) – 2025

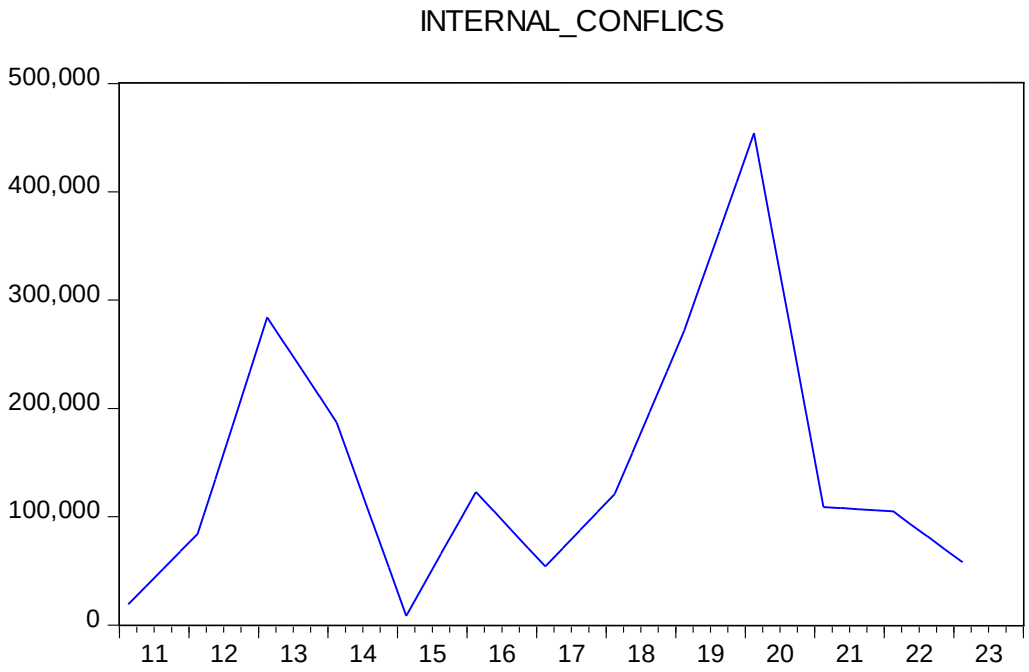

Figure 3: illustrates the internal conflicts variable at the level form.

Source: Researcher's data from study data (EViews) – 2025

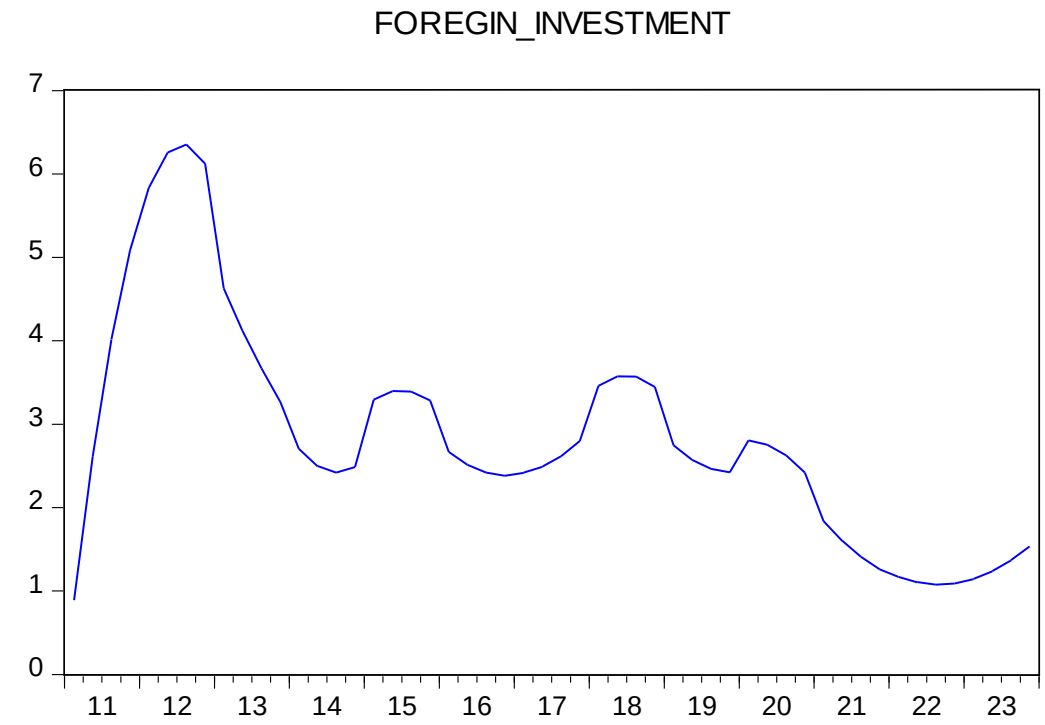

Figure 4: illustrate the foreign direct investment variable before taking the first difference.

Source: Researcher's data from study data (EViews) – 2025

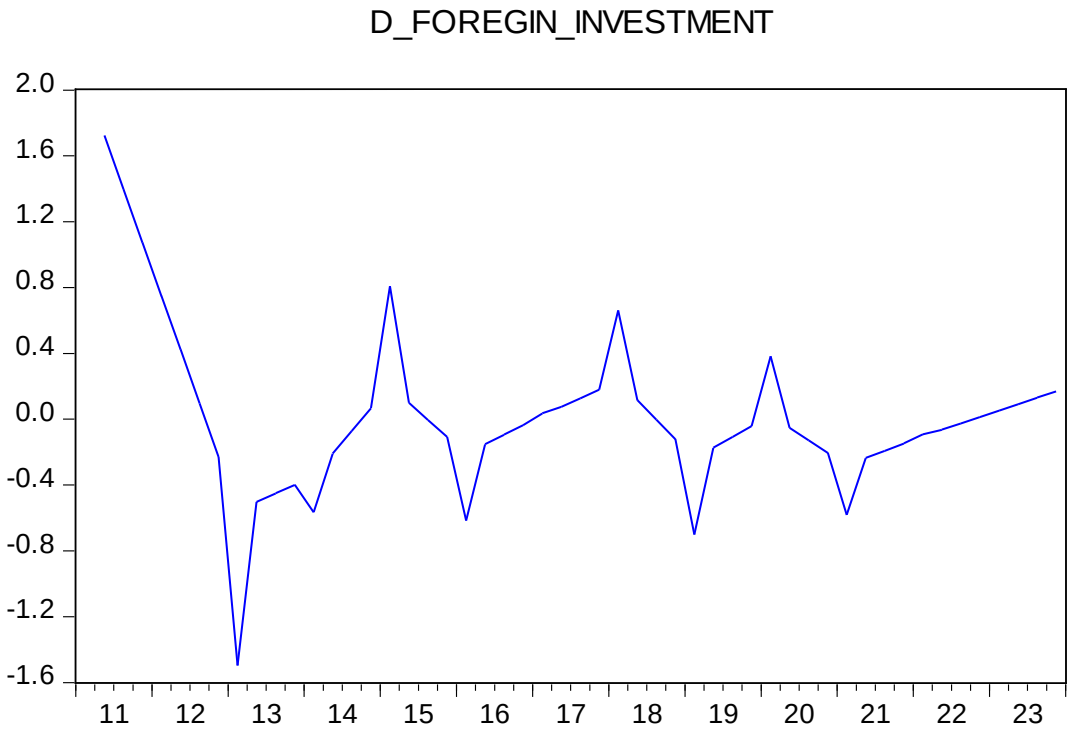

Figure 5: illustrates the foreign direct investment variable after taking the first difference.

Source: Researcher's data from study data (EViews) – 2025

4.3 Third: Estimation of the Logistic Regression Model

To estimate the logistic regression model, the study used the following function:

$\ln\left(\frac{P(x)}{p_{-1}(x)}\right) = \beta + \beta_1(x_1) + \beta_2(x_2) + \beta_3(x_3) + \beta_4(x_4)$Where:

P(X) = Probability of the occurrence of an economic crisis

β_0 = Regression intercept

X_1 = Inflation

X_2 = Internal conflicts

X_3 = Foreign direct investment

X_4 = Political changes

A binary logistic regression model was estimated to measure the effect of the independent variables on the likelihood of an economic crisis occurring, as shown in the following table:

Table 6: A binary logistic regression model

Variable	Coefficient (β)	Standard Error	Wald Test Value	P-value	Statistical Significance
Inflation	-0.005	0.026	1.916742	0.062	Not statistically significant
Internal Conflicts	0.0001	0.0002	2.168730	0.035	Statistically significant
Foreign Direct Investment	3.478	1.345	2.586091	0.013	Statistically significant
Political Changes	1.824	0.952	1.917	0.047	Statistically significant
Intercept	-1.922	0.812	-2.365461	0.012	Statistically significant

Source: Prepared by the researcher based on the study data (EViews) – 2025

From the table above, the following observations can be made:

The variable Inflation has a p-value greater than the significance level (0.05), which means it is not statistically significant. In other words, inflation does not affect the occurrence of economic crises.

The variable Internal Conflicts have a p-value less than 0.05, indicating it is statistically significant. This means that internal conflicts influence the occurrence of economic crises. Given the positive coefficient value (0.0001), it can be said that the relationship is direct between internal conflicts and the probability of a crisis.

The variable Foreign Direct Investment also has a p-value of less than 0.05, so it is statistically significant. This implies that increases in foreign investment affect the occurrence of economic crises. The positive coefficient value (3.478) suggests a direct relationship between FDI and the likelihood of a crisis.

The variable Political Changes have a p-value below 0.05 and are statistically significant, indicating that political changes affect economic crises. The positive coefficient (1.824) points to a direct relationship between political changes and the probability of a crisis.

Accordingly, the logistic regression equation can be formulated as follows:

$$\ln\left(\frac{P(x)}{p_{-1}(x)}\right) = -1.922 + +0.0001(x_2) + 3.478(x_3) + 1.824(x_4)$$ **Where:**

X_2 = Internal Conflicts

X_3 = Foreign Direct Investment

X_4 = Political Changes

Note: The Inflation variable was excluded due to its lack of significant effect on the probability of an economic crisis.

Economic Interpretation of the Model

The statistically significant effect of Internal Conflicts aligns with economic theory, as political and security instability increases the risk of economic crises.

The positive impact of Foreign Direct Investment on economic crises may be due to unstable investment flows, reflecting the fragility of the investment environment in Sudan.

The significant effect of Political Changes also aligns with economic theory, where political instability such as coups and government changes increase the chances of economic crises.

The insignificance of Inflation suggests that it may not be a key indicator of economic crises in Sudan during the studied period.

4.4 Fourth: ROC Curve

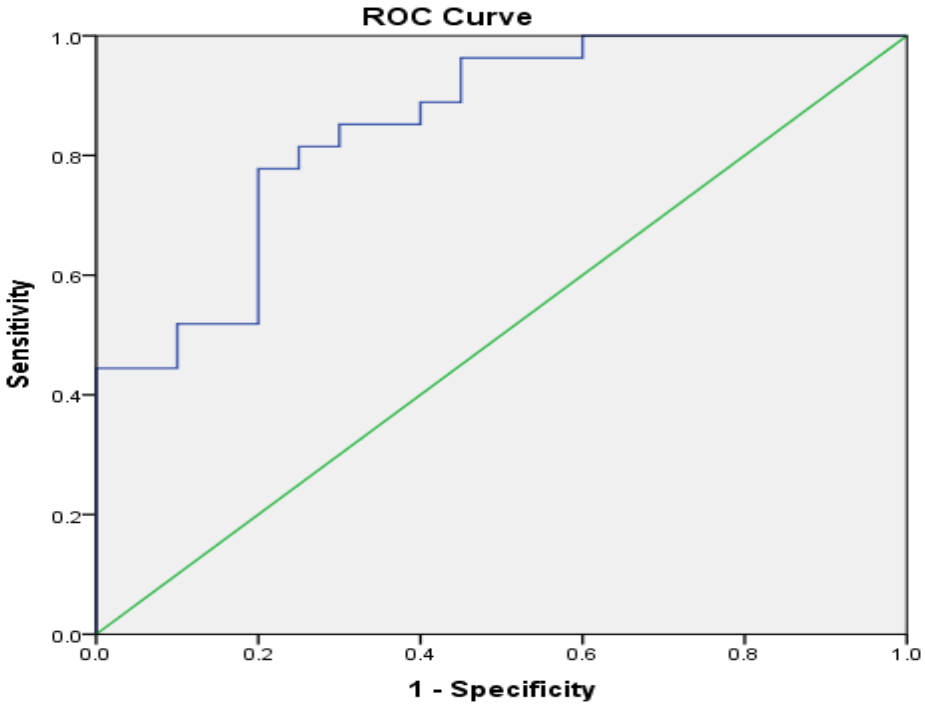

Figure 6: ROC Curve

Source: Researcher's data from study data– 2025

The figure above illustrates the Receiver Operating Characteristic (ROC) curve, which reflects the model's efficiency in distinguishing between economic crisis events and non-crisis periods. The curve's proximity to the upper left corner indicates a high classification ability. The Area Under the Curve (AUC) was found to be (0.85),

suggesting that the model possesses a (good) level of accuracy in discriminating between the two categories. Based on these results, the model can be considered appropriate for predicting economic crises within the sample studied.

These findings confirm that the balance between the True Positive Rate and the False Positive Rate is adequate to achieve the analytical purpose of the study.

4.5 Fifth: Model Goodness-of-Fit Test

Table No. (7) shows: **Model Goodness-of-Fit Test**

Test	Value	P-value	Statistical Significance
Hosmer-Lemeshow Test	7.7555	0.457	Not statistically significant

Source: Prepared by the researcher based on the study data (EViews) – 2025

The table above shows the value of the Hosmer-Lemeshow Test, which is used to test the model's goodness of fitness. The p-value (0.457) is greater than the significance level (0.05), indicating that the model is a good fit for the data.

5. **Conclusion**: Including Findings and Recommendations

5.1 First: Findings

Internal conflicts and political changes are major factors influencing the likelihood of economic crises in Sudan.

Foreign direct investment positively impacts the probability of economic crises, indicating the fragility of its inflows in Sudan.

Foreign direct investment (FDI) in Sudan during the study period was concentrated in non-productive sectors, such as real estate and services, and did not contribute to fostering sustainable economic growth. This contributed to the exacerbation of economic imbalances, thus leading to a positive association with the occurrence of economic crises. This finding is consistent with the World Bank reports on Sudan, which indicate that FDI inflows lacked proper orientation towards productive and vital sectors (World Bank, 2020).

Inflation has no statistically significant impact on the likelihood of economic crises, warranting a re-evaluation of its role in future studies.

The logistic regression model proved effective in analyzing the factors influencing economic crises by accurately identifying the most impactful variables.

Statistical tests such as Hosmer-Lemeshow and Wald showed that the model has high quality and predictive accuracy.

5.2 second: Recommendations

It is necessary to enhance political stability through government policies that support security and development.

Work on regulating and organizing foreign direct investment to ensure its sustainability and direct it toward productive sectors.

Conduct additional studies that include other factors such as monetary policy and foreign exchange markets.

Develop advanced analytical models that combine time-series models and logistic regression for more accurate crisis analysis.

Use logistic regression in economic policies as a predictive tool to help decision-makers take preventive measures against potential crises.

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