Time Series Analysis: A Model Solution for Addressing Nigeria's Economic Challenges

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Abstract

This study undertakes a comprehensive time series analysis of Nigeria's economic data from 2010 to 2023, focusing on key indicators such as GDP, inflation rate, unemployment rate, exchange rate, foreign direct investment (FDI), government revenue, and expenditure. Utilizing the ARIMA (Autoregressive Integrated Moving Average) model, we aim to forecast future economic trends and provide actionable insights for policy-making. Our analysis reveals significant volatility in Nigeria's economic indicators over the studied period. The GDP showed fluctuations, peaking in 2014 before experiencing a decline due to the 2016 recession, followed by gradual recovery. The inflation rate remained high, peaking at 19.5% in 2023, reflecting persistent inflationary pressures. Unemployment showed a troubling upward trend, reaching a height of 35.0% in 2021, indicating structural economic issues. The exchange rate exhibited substantial depreciation, while FDI inflows showed a declining trend, highlighting challenges in attracting foreign investment. Correlation analysis revealed critical relationships between these indicators: higher inflation rates and unemployment are associated with lower GDP growth, while higher exchange rates (weaker currency) associate with higher inflation. The ARIMA model forecast for GDP suggests continued recovery, but with significant uncertainties. The findings underscore the need for diversified economic strategies, effective inflation control measures, targeted job creation policies, and improved conditions for FDI. These insights are crucial for policymakers aiming to stabilize and grow Nigeria's economy. This study highlights the importance of data-driven approaches in addressing economic challenges and promoting sustainable growth in Nigeria.
Keywords: ARIMA Model, Time Series Analysis, Macroeconomic Indicators, Nigeria's Economy, Forecasting.

Introduction

Nigeria, Africa's largest economy, has experienced significant economic fluctuations over the past decade, influenced by both internal and external factors. As a resource-rich country, Nigeria's economy according to OPEC (2023) is heavily dependent on oil, which has historically contributed to both rapid economic growth and severe volatility. Understanding the dynamics of Nigeria's economic indicators is crucial for developing effective policies to promote sustainable growth and stability. Economic data from 2010 to

2023 reveal several key trends and challenges. The Gross Domestic Product (GDP) has shown significant variability, influenced by factors such as global oil prices, political stability, and domestic economic policies (World Bank, 2023). Inflation rates have remained high, often driven by currency depreciation and supply-side constraints (IMF, 2022). Unemployment rates have also been a persistent issue, reflecting structural problems within the economy (National Bureau of Statistics, 2023).

Time series analysis, particularly the ARIMA (Autoregressive Integrated Moving Average) model, is employed in this study to analyze these economic indicators and forecast future trends. The ARIMA model is well-suited for economic forecasting as it can handle various components of time series data, including trend and seasonality (Box et al., 2015). By fitting this model to Nigeria's economic data, we aim to capture the underlying patterns and make reliable forecasts. Correlation analysis is also conducted to identify significant relationships between different economic indicators. previous studies by Blanchard (2020) and Mishkin (2022) have shown that inflation and unemployment rates are often inversely related to GDP growth, highlighting the need for balanced economic policies (Blanchard & Johnson, 2013). Understanding these relationships can provide a comprehensive view of the economic landscape and help in formulating effective policy responses.

This study aims to contribute to the existing literature on Nigeria's economic analysis and offer practical insights for policymakers. By analyzing the trends and dynamics of key economic indicators, policymakers can develop targeted strategies to address economic challenges and promote sustainable growth. This study underscores the importance of continuous monitoring and analysis of economic data in formulating effective economic policies. The findings are expected to inform policymakers about the current state and future prospects of Nigeria's economy, guiding decisions on fiscal and monetary policies, investment strategies, and other economic interventions. Addressing the identified challenges requires a data-driven approach to understand the relationships between different economic indicators and to make informed policy decisions.

Literature Review
Overview
The economic landscape of Nigeria has been extensively studied, focusing on various macroeconomic indicators such as GDP, inflation, unemployment, exchange rates, and foreign direct investment (FDI). Recent studies Bhana (2022) and Dincer (2020) have highlighted the importance of understanding the dynamics of these indicators to formulate effective policies for sustainable growth.

i. GDP and Economic Growth
Recent research has shown that Nigeria's GDP growth has been significantly influenced by oil price fluctuations, with oil being a major contributor to the nation's revenue (Adegboye & Ibrahim, 2022). Alade and Owolabi (2023) used the ARDL approach to demonstrate that monetary policy significantly impacts economic growth, emphasizing the need for prudent

fiscal management. Afolabi and Akinpelu (2023) further highlighted the crucial role of infrastructure development in driving economic growth in Nigeria.

ii. Inflation

Inflation remains a persistent issue in Nigeria's economy. Adegboye and Ibrahim (2022) explored the effects of different exchange rate regimes on inflation volatility, concluding that a stable exchange rate regime can help control inflation. Okon and Ekpenyong (2023) applied the ARDL bounds test to investigate the relationship between inflation, exchange rates, and economic growth, finding that high inflation rates negatively impact economic growth.

iii. Unemployment

High unemployment rates continue to be a significant challenge for Nigeria. Recent studies, such as Njoku and Okoye (2023), have emphasized the need for targeted fiscal policies to address structural unemployment. The authors argue that investment in education and vocational training is essential to equip the labor force with the necessary skills for the modern economy.

iv. Exchange Rates

The volatility of Nigeria's exchange rates has been a topic of much research. Akinbobola and Yusuf (2022) examined the impact of exchange rate volatility on economic growth, finding that fluctuations in the exchange rate can have adverse effects on economic stability. They recommend policies aimed at stabilizing the exchange rate to foster economic growth (Ghosho, 2019 & Frankel, 2019).

v. Foreign Direct Investment (FDI)

FDI is crucial for economic development, and recent studies have focused on its determinants and effects in Nigeria. Odili and Ekeocha (2022) analyzed the long-run and causal relationships between FDI and economic growth, concluding that FDI positively impacts growth, provided that there is a conducive business environment. Omodero and Ogbonnaya (2023) further explored how government expenditure influences economic growth, emphasizing the need for strategic investment to attract more FDI.

The study of Nigeria's macroeconomic indicators, especially through time series analysis, has gained increasing attention in economic research. Several scholars have attempted to model Nigeria's economic challenges, such as inflation, unemployment, and exchange rate volatility, using various quantitative methods. However, there remain significant gaps in the current body of literature, especially in terms of the application of recent data and comprehensive multi-variable modeling. This review critically synthesizes the key studies on Nigeria's macroeconomic performance and identifies the gaps that the current study aims to address.

1. Macroeconomic Indicators and Economic Performance

Numerous studies have explored the relationship between macroeconomic indicators such as inflation, GDP growth, and exchange rates in Nigeria. For instance, Adeniji (2019) examined the effects of inflation and exchange rate instability on economic growth, concluding that exchange rate volatility negatively impacted Nigeria's GDP. Similarly, Olawale and Adebisi (2020) conducted an analysis of unemployment rates and found that youth unemployment, in particular, is closely connected to inflation and slow economic growth. However, these studies often consider individual indicators in isolation rather than taking a holistic, time-series approach to understanding the interplay between multiple variables over time.

Moreover, previous studies tend to rely on data that may not capture recent economic shocks, such as the impact of the COVID-19 pandemic on global oil prices and Nigeria's economic downturn. For example, Adamu (2018) employed historical data to investigate GDP trends and inflation but did not account for significant disruptions like the oil price crash in 2020, which severely affected Nigeria's foreign exchange earnings and economic stability. The significant hole here is that many of these studies fail to incorporate recent, significant global and local economic events and do not offer a dynamic model that integrates multiple macroeconomic variables.

2. Application of Time Series Models in Nigeria's Economy

Time series models have been employed in various studies to analyze and forecast Nigeria's macroeconomic variables. Usman and Salisu (2017) applied an ARIMA model to forecast Nigeria's inflation rate, finding that short-term predictions were moderately accurate, but the model struggled with longer-term forecasts due to unaccounted structural breaks in the economy. Similarly, Okonjo-Iweala and Garba (2021) applied a VAR model to study the relationship between exchange rates and inflation. They concluded that the models could provide some predictive power but did not fully capture the volatility in Nigeria's economic data, especially in response to external shocks like oil price fluctuations.

While time series models such as ARIMA and VAR are commonly used, few studies have critically compared these models or used hybrid models (e.g., GARCH for volatility clustering). More recent studies, such as Tukur and Bello (2022), recommend combining models for improved accuracy in handling Nigeria's erratic macroeconomic data. However, there has been limited research using recent data, especially post-pandemic, which presents new economic dynamics, such as changes in global trade patterns, oil demand, and local production capacities. The significant hole here is that earlier research often relies on older models that are not adjusted for significant, more recent economic changes. There is a lack of studies using hybrid models or those incorporating more recent data and global economic dynamics.

3. Global Oil Price Volatility and its Impact on Nigeria

As an oil-dependent economy, fluctuations in global oil prices have profound effects on Nigeria's macroeconomic indicators. Babatunde and Elegbede (2016) explored the correlation between oil price shocks and exchange rate volatility, concluding that Nigeria's currency is highly vulnerable to global oil price fluctuations. Sanusi (2020) expanded on this by examining how oil price shocks influence inflation and found that a decrease in oil prices leads to inflationary pressures, as the government's revenue shrinks, leading to increased borrowing and monetary expansion.

While these studies provide valuable insights, they often focus solely on the oil price as an external factor, overlooking other significant influences like global trade dynamics, foreign direct investment (FDI), or political instability. Additionally, most of these studies are pre-2020 and do not consider the compounding effects of the COVID-19 pandemic and how it altered global demand and supply chains for oil.

Since most of these studies are pre-2020 and do not reflect on the deepening effects of the COVID-19 pandemic and the alteration of the global demand and supply chains for oil, there is a need for studies that integrate not just oil price volatility but also other external factors such as global economic trends, domestic policy shifts, and political factors that affect Nigeria's economy.

4. Macroeconomic Policy and Forecasting

Several studies have examined Nigeria's economic policies and their impact on macroeconomic stability. Ekpo and Umoh (2018) discussed how inconsistent monetary and fiscal policies have intensified Nigeria's economic volatility, particularly in terms of inflation control and exchange rate management. They argued that better policy coordination between the Central Bank and the Ministry of Finance could mitigate some of these issues. However, their study did not offer a forecasting model to predict how different policy measures would affect the economy over time. Adewumi and Salami (2021) employed economic simulations to suggest that reducing dependence on oil revenues could stabilize Nigeria's currency and inflation rates. However, their simulations were based on historical data, and there is limited empirical analysis on how current fiscal and monetary policies might evolve given the unpredictable nature of the global economy. Most studies offer policy recommendations based on historical analysis rather than predictive models. This research will develop a time series forecasting model that can provide policymakers with a forward-looking tool to anticipate economic challenges and implement proactive measures.

Problem Statement

Nigeria's economy has faced persistent challenges over the past few decades, characterized by high inflation, volatile exchange rates, rising unemployment, and slow GDP growth. Despite being one of the largest economies in Africa, Nigeria remains weak to global oil price fluctuations, weak infrastructure, and inconsistent economic policies, all of

which have contributed to macroeconomic instability. These challenges are further worsened by political instability, insecurity, and lack of diversification away from oil dependency. Current economic policies have not sufficiently addressed these issues, leading to frequent crises such as currency devaluation, inflationary spikes, and high poverty levels. The absence of comprehensive and data-driven approaches to economic forecasting and planning have limited the ability of policymakers to anticipate and ease these problems.

The purpose of this study is to conduct a time series analysis of Nigeria's key macroeconomic indicators, including GDP, inflation rate, exchange rate, and unemployment rate, in order to develop a predictive model that can provide insights into future economic trends. The study aims to identify patterns, trends, and correlations between these indicators, which can be used to better inform economic policies and decision-making. By leveraging time series models, this research will offer a tool for addressing Nigeria's ongoing economic issues. Accurately predicting future economic performance can empower policymakers to adopt timely and effective measures to stabilize the economy, control inflation, enhance employment opportunities, and manage exchange rate volatility. In essence, this study seeks to contribute to a more stable and resilient Nigerian economy, ensuring long-term growth and development.

Research Objectives

1. To analyze the historical trends of Nigeria's key macroeconomic indicators, including GDP growth, inflation rate, unemployment rate, and exchange rate, over a defined period.
2. To develop a time series model using ARIMA, that can effectively predict future values of these macroeconomic indicators.
3. To identify correlations between the macroeconomic indicators and external factors that influence Nigeria's economy.
4. To assess the accuracy and reliability of the time series model for forecasting Nigeria's future economic trends.
5. To contribute to the literature on economic forecasting and provide a data-driven approach that can be used by policymakers for effective economic planning.

Research Questions

1. What are the historical trends in Nigeria's key macroeconomic indicators (GDP, inflation, unemployment, and exchange rate) over the selected time period?
2. What is the most appropriate time series model for forecasting future values of Nigeria's macroeconomic indicators, and how accurate is the model?
3. What are the relationships and correlations between Nigeria's macroeconomic indicators and external economic factors (e.g., oil prices, global economic shocks)?

4. How can the time series model's forecasts be used to address specific economic challenges faced by Nigeria, such as inflation, exchange rate volatility, and unemployment?
5. What policy recommendations can be derived from the time series analysis to ensure sustainable economic growth and stability in Nigeria?

Methodology for Time Series Analysis of Nigeria's Economic Data

1. Data Collection

The data for this study will consist of Nigeria's key macroeconomic indicators, including: GDP growth rate, Inflation rate, Exchange rate, Unemployment rate. These indicators will be collected on a quarterly basis for the period spanning from 2000 to 2023, ensuring that both pre- and post-COVID-19 data are included. The data will be sourced from reputable institutions such as the National Bureau of Statistics (NBS), World Bank, and International Monetary Fund (IMF) databases.

2. Selection of ARIMA Model

The Autoregressive Integrated Moving Average (ARIMA) model is selected for this study to forecast Nigeria's macroeconomic indicators. The ARIMA model is one of the most widely used time series forecasting methods due to its ability to model complex patterns, including trend, seasonality, and noise, while requiring relatively little computational effort compared to more advanced models. The choice of the ARIMA model for this analysis is justified by the following justifications for the selection of ARIMA:

i. Flexibility in Modeling Data: ARIMA is capable of handling various types of time series data, including non-stationary data, which is common in economic indicators. By incorporating differencing (the "I" component in ARIMA), the model is effective at transforming non-stationary data into stationary form, making it suitable for most economic time series.

ii. Captures Past Behavior: The ARIMA model leverages both the autoregressive (AR) and moving average (MA) components, which allows it to capture the relationships between past observations and current values. This is important for modeling economic indicators like inflation or GDP growth, which often depend on their past values.

iii. Handles Trend and Noise: ARIMA is particularly useful when time series data exhibit trends or irregular fluctuations. Through differencing, the model accounts for trends, and by including moving averages, it smooths out noise or random fluctuations.

iv. Forecasting Capability: ARIMA's primary strength is in its forecasting ability, particularly for short-term forecasts. Given that economic indicators often exhibit lagged effects, ARIMA models can accurately capture these relationships and provide reliable short- and medium-term forecasts.

v. Simplicity: Unlike more complex models such as Vector Autoregression (VAR) or Generalized Autoregressive Conditional Heteroskedasticity (GARCH), ARIMA is simpler to implement and interpret. This makes it a suitable choice for the study, especially given the need to forecast multiple indicators while maintaining model transparency.

3. Model Selection Process

The ARIMA model will be selected based on the following steps:

Stationarity Testing: First, the stationarity of the macroeconomic indicators will be tested using the Augmented Dickey-Fuller (ADF) test. If the data is non-stationary, differencing will be applied to make it stationary.

Identification of ARIMA Order (p, d, q): The order of the ARIMA model, denoted as (p, d, q), will be identified through the analysis of the Autocorrelation Function (ACF) and the Partial Autocorrelation Function (PACF) plots. The parameters will be defined as:

P: The number of autoregressive terms (lags of the dependent variable).

D: The number of differencing required to achieve stationarity.

Q: The number of lagged forecast errors included in the model.

Model Selection Criteria: Models with different (p, d, q) combinations will be evaluated based on the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The model with the lowest AIC/BIC values will be selected as the best-fitting model.

4. Criteria for Evaluating Model Performance

To assess the performance and accuracy of the ARIMA model, the following evaluation metrics will be used:

4.1 Mean Absolute Error (MAE)

Definition: MAE is the average of the absolute differences between the actual and predicted values. It is calculated as:

Justification: MAE is a widely used metric because it provides an intuitive measure of average forecast error. Unlike other metrics, MAE penalizes all errors equally, making it useful for understanding the magnitude of errors without amplifying large deviations. For economic forecasts, where understanding the typical error size is crucial, MAE is particularly informative.

4.2 Mean Squared Error (MSE)

Definition: MSE is the average of the squared differences between actual and predicted values. It is calculated as:

4.3 Root Mean Squared Error (RMSE)

Definition: RMSE is the square root of the MSE. It is used to provide error metrics in the same units as the original data, making it easier to interpret.

4.4 Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC)

Definition: Both AIC and BIC are used for model selection by balancing model fit with complexity. The lower the AIC/BIC, the better the model in terms of predictive power and simplicity.

Justification: AIC and BIC are particularly useful for comparing different ARIMA models with varying p, d, q parameters. They help avoid overfitting by penalizing models with too many parameters. For economic models, which often involve complex interdependencies, using AIC and BIC helps to ensure that the selected model is both parsimonious and accurate.

5. Model Validation

Once the ARIMA model is selected, it will be validated using out-of-sample testing. This involves dividing the data into a training set and a test set. The model will be trained on the training set and its performance will be evaluated on the test set using the previously discussed evaluation metrics (MAE, MSE, RMSE). This ensures that the model can generalize beyond the data it was trained on.

6. Forecasting and Policy Implications

After model validation, the ARIMA model will be used to forecast future values of Nigeria's macroeconomic indicators. The forecast results will be analyzed for trends and patterns, and the study will conclude with policy recommendations based on the projected future economic conditions. These recommendations will aim to address Nigeria's major economic challenges, such as inflation control, exchange rate stability, and unemployment reduction, using insights derived from the ARIMA forecasts.

In conclusion, the ARIMA model is chosen for its flexibility, accuracy in short-term forecasting, and simplicity in implementation. The evaluation metrics (MAE, MSE, RMSE) and model selection criteria (AIC, BIC) will ensure that the model is both accurate and efficient in forecasting Nigeria's macroeconomic indicators.

Time series analysis can be an effective tool for addressing economic issues in Nigeria (Olorunfemi & Ogunleye, 2022 and Adebayo & Adegboye, 2021). By analyzing past data trends, it is possible to forecast future economic conditions and develop strategies to improve the economic situation. Here is a model solution to approach Nigeria's economic situation using time series analysis:

i. Sources Data Collection

National Bureau of Statistics (NBS) of Nigeria, World Bank, International Monetary Fund (IMF) and Central Bank of Nigeria (CBN).

   a. Gross Domestic Product (GDP)
   b. Inflation Rate
   c. Unemployment Rate
   d. Exchange Rate (Naira to USD)
   e. Foreign Direct Investment (FDI)

f. Government Revenue

g. Government Expenditure

ii. Data Preprocessing

a. Cleaning: Handle missing values using interpolation or imputation techniques.

b. Outliers: Detect and handle outliers using statistical methods or visual inspection.

c. Transformation: Apply transformations (e.g., log transformation) if necessary to stabilize variance.

d. Normalization: Normalize data if required to bring all indicators to a comparable scale (Patro et. al, 2021).

e. Stationarity Check: Use the Augmented Dickey-Fuller (ADF) test to check for stationarity. If the series is non-stationary, differencing or detrending methods will be applied to achieve stationarity.

iii. Exploratory Data Analysis (EDA)

a. Trend Analysis: Plot time series graphs for each indicator to identify trends over time.

b. Seasonality Analysis: Check for seasonal patterns using seasonal decomposition of time series.

c. Correlation Analysis: Calculate and plot the correlation matrix to identify relationships between different indicators.

iv. Model Selection

Depending on the characteristics of the data, select appropriate model for time series analysis and the possible Models are:

a. ARIMA (Autoregressive Integrated Moving Average): For univariate time series data.

b. SARIMA (Seasonal ARIMA): For data with seasonal patterns.

c. VAR (Vector Autoregression): For multivariate time series data.

d. GARCH (Generalized Autoregressive Conditional Heteroskedasticity): For modeling volatility.

e. LSTM (Long Short-Term Memory): For capturing long-term dependencies using deep learning.

v. Model Training and Validation

a. Training: Split the data into training and testing sets. Train the selected model on the training set.

b. Validation: Validate the model on the testing set using evaluation metrics such as Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE) or correlation coefficient (R) for evaluation.

vi.　Forecasting
a. Use the trained model to make forecasts for future values of each economic indicator.
b. Generate confidence intervals to understand the uncertainty in the forecasts.

vii.　Policy Simulation
a. Simulate different policy scenarios using the forecasted data to evaluate potential impacts on the economy.
b. Assess the effects of changes in interest rates, government spending, or tax policies.

viii.　Decision Making and Implementation
a. Present findings to policymakers.
b. Recommend actionable strategies based on the forecasts and simulations.
c. Implement the recommended policies and monitor their impact over time.
ix. Analysis on ARIMA Model for GDP Forecasting

Step-by-Step Implementation

a. Import Libraries

python
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```
import pandas as pd

import numpy as np

from statsmodels.tsa.statespace.sarimax import SARIMAX

from statsmodels.tsa.stattools import adfuller

import matplotlib.pyplot as plt

import seaborn as sns
```

b. Load Data

python
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```
data = pd.read_csv('nigeria_economic_data.csv', index_col='Year', parse_dates=True)

gdp = data['GDP']

inflation = data['Inflation']

unemployment = data['Unemployment']

exchange_rate = data['Exchange Rate']
```

fdi = data['FDI']

revenue = data['Government Revenue']

expenditure = data['Government Expenditure']

c. Check for Stationarity

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result = adfuller(gdp)

print('ADF Statistic:', result[0])

print('p-value:', result[1])

d. Visualize Data

python
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 # Plotting GDP trend

plt.figure(figsize=(10, 5))

plt.plot(gdp, marker='o')

plt.title('GDP Trend in Nigeria (2010-2023)')

plt.xlabel('Year')

plt.ylabel('GDP (USD Billion)')

plt.grid(True)

plt.show()

 # Plotting correlation matrix

data_for_corr = data[['GDP', 'Inflation', 'Unemployment', 'Exchange Rate', 'FDI']]

corr_matrix = data_for_corr.corr()

plt.figure(figsize=(10, 8))

sns.heatmap(corr_matrix, annot=True, cmap='coolwarm', linewidths=0.5)

plt.title('Correlation Matrix of Nigeria Economic Indicators (2010-2023)')

plt.show()

e. Fit ARIMA Model

python
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```
model = SARIMAX(gdp, order=(1, 1, 1))

results = model.fit()
```

f. Make Forecast

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```
forecast = results.get_forecast(steps=3)

forecast_index = pd.date_range(start='2024', periods=3, freq='Y')

forecast_series = pd.Series(forecast.predicted_mean, index=forecast_index)

conf_int = forecast.conf_int()

# Plotting the forecast

plt.figure(figsize=(10, 5))

plt.plot(gdp, label='Actual GDP')

plt.plot(forecast_series, label='Forecasted GDP', color='red')

plt.fill_between(forecast_index, conf_int.iloc[:, 0], conf_int.iloc[:, 1], color='k', alpha=0.2)

plt.title('GDP Forecast for Nigeria (2024-2026)')

plt.xlabel('Year')

plt.ylabel('GDP (USD Billion)')

plt.legend()

plt.grid(True)

plt.show()
```

g. Plot Results

python
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```
plt.figure(figsize=(10, 5))

plt.plot(gdp, label='Actual')

plt.plot(forecast_df['Predictions'], label='Forecast')
```

plt.fill_between(forecast_df.index, forecast_df['lower GDP'], forecast_df['upper GDP'], color='k', alpha=0.2)

plt.legend()

plt.show()

    h. Interpretation
    i. GDP Trend: Analyze the historical trend and forecasted values to understand economic growth.
    ii. Inflation and Unemployment: Understand how these indicators have changed over time and their impact on the economy.
    iii. Correlation Analysis: Identify significant relationships between economic indicators to inform policy decisions.
    iv. Forecasting: Use the forecasts to make informed decisions on economic policies and strategies.

This methodology provides a comprehensive framework for analyzing and forecasting economic indicators for Nigeria, helping to make data-driven policy decisions.

The general form of the ARIMA model is given by:

$$ARIMA(p, d, q)$$

Where:

p is th order of the autoregressive (AR) part.

d is the degree of differencing.

q is the order of the moving average (MA) part.

The ARIMA model equation can be written as:

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + \theta_1 \epsilon_{t-1} + \theta_2 \epsilon_{t-2} + \cdots + \theta_q \epsilon_{t-q} + \epsilon_t$$

Where:

y_t is the value of the time series at time t.

c is a constant.

$\phi_1, \phi_2, \ldots, \phi_p$ are the coefficients of the autoregressive terms.

$\theta_1, \theta_2, \ldots, \theta_q$ are the coefficients of the moving average terms.

ϵ_t is the error term at time t.

Fitting the ARIMA Model

For this analysis, let's assume we fit an ARIMA(1, 1, 1) model to the GDP data. The equation for the ARIMA(1, 1, 1) model is:

$\Delta y_t = c + \phi_1 \Delta y_{t-1} + \theta_1 \epsilon_{t-1} + \epsilon_t$

Where:

$\Delta y_t = y_t - y_{t-1}$ represents the first difference of the time series, which is used to make the series stationary.

Steps to Fit the ARIMA Model

i.   Differencing the Series: To make the series stationary, we take the first difference of the GDP series.

ii. Estimating Parameters: Estimate the parameters ϕ_1 and θ_1 using maximum likelihood estimation.

iii. Model Fitting: Fit the ARIMA (1, 1, 1) model to the differenced series.

iv. Forecasting: Use the fitted model to forecast future values.

Using Python and the statsmodels library, we can fit the ARIMA (1, 1, 1) model and obtain the coefficients.

python
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```
import pandas as pd

import numpy as np

from statsmodels.tsa.statespace.sarimax import SARIMAX

# GDP time series data (example)

years = pd.date_range(start='2010', periods=14, freq='Y')

gdp = [369.1, 411.7, 461.1, 514.9, 568.5, 493.8, 404.6, 375.8, 397.3, 448.1, 432.3, 440.8, 477.4, 490.0]

gdp_series = pd.Series(gdp, index=years)

# Fitting the ARIMA model

model = SARIMAX(gdp_series, order=(1, 1, 1))

results = model.fit()

# Displaying the results

print(results.summary())
```

The output will include the estimated coefficients for ϕ_1\phi_1ϕ_1 (AR term), θ_1\theta_1θ_1 (MA term), and the constant ccc.

Interpreting the Results

Assuming the output gives the following estimated coefficients:

$c=10c = 10c=10$

$\phi_1=0.5$\phi_1 = 0.5$\phi_1=0.5$

$\theta_1=0.3$\theta_1 = 0.3$\theta_1=0.3$

The ARIMA(1, 1, 1) model equation for the GDP series becomes:

$\Delta y_t=10+0.5\Delta y_{t-1}+0.3\epsilon_{t-1}+\epsilon_t$\Delta y_t = 10 + 0.5 \Delta y_{t-1} + 0.3 \epsilon_{t-1} + \epsilon_t$\Delta y_t=10+0.5\Delta y_{t-1}+0.3\epsilon_{t-1}+\epsilon_t$

Where:

Δy_t\Delta y_tΔy_t is the first difference of the GDP at time ttt.

ϵ_t\epsilon_tϵ_t is the error term at time ttt.

Forecasting Future Values

Using the fitted model, we can forecast future GDP values. The getforecast method provides the predicted mean and confidence intervals for the forecasted periods.

python
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```python
forecast = results.get_forecast(steps=3)

forecast_mean = forecast.predicted_mean

conf_int = forecast.conf_int()

# Displaying the forecasted values

print(forecast_mean)

print(conf_int)
```

This will give the forecasted GDP values for the next 3 years along with their confidence intervals.

The ARIMA model provides a mathematical framework for analyzing and forecasting time series data. By fitting an ARIMA (1, 1, 1) model to the GDP data, we can capture the underlying patterns and make informed predictions about future economic trends. The model's coefficients offer insights into the relationships between past and future values, and the forecasts help in planning and decision-making for economic policies.

Data Analysis

Let's proceed with the analysis of the economic data for Nigeria from 2010 to 2023. We will use tables, charts, graphs, and equations to illustrate the trends and relationships among the key economic indicators.

i. Data Preparation

First, let's prepare the data in tabular format for easier analysis.

Table 1: Nigeria Economic Data (2010-2023)

Year	GDP (USD) Billion	Inflation Rate (%)	Unemploy-ment Rate (%)	Exchange Rate (NGN /USD)	FDI Rate (USD) Billion	Govt. Revenue (USD)	Govt. Expenditure (USD)
2010	369.1	13.7	6.4	150.3	6.1	45.0	29.4
2011	411.7	10.8	7.4	155.2	8.9	60.3	34.6
2012	461.1	12.2	8.2	157.5	7.0	68.6	39.5
2013	514.9	8.5	8.5	157.3	5.6	71.1	45.6
2014	568.5	8.0	7.8	168.0	4.7	76.8	53.5
2015	493.8	9.0	9.0	196.5	3.1	52.0	41.5
2016	406.6	15.7	13.4	304.3	4.4	36.2	32.4
2017	375.8	16.5	18.8	367.0	3.5	43.4	34.2
2018	397.3	12.1	23.1	361.0	2.2	54.1	41.8
2019	448.1	11.4	27.1	360.5	2.3	61.0	47.6
2020	432.3	13.2	33.3	380.0	2.4	49.4	49.7
2021	440.8	16.4	35.0	410.5	2.0	55.2	52.1
2022	477.4	18.6	33.0	440.0	2.5	60.0	55.0
2023	490.0 (est.)	19.5 (est.)	32.5 (est.)	460.0 (est.)	2.8 (est.)	65.0 (est.)	58.0 (est.)

Source: National Bureau of Statistics (NBS) of Nigeria, World Bank, International Monetary Fund (IMF) and Central Bank of Nigeria (CBN).

ii. GDP Trend

python
Copy code

```
import pandas as pd

import matplotlib.pyplot as plt

# Data preparation

years = list(range(2010, 2023 + 1))

gdp = [369.1, 411.7, 461.1, 514.9, 568.5, 493.8, 404.6, 375.8, 397.3, 448.1, 432.3, 440.8, 477.4, 490.0]
```

```
# Plotting GDP trend

plt.figure(figsize=(10, 5))

plt.plot(years, gdp, marker='o')

plt.title('GDP Trend in Nigeria (2010-2023)')

plt.xlabel('Year')

plt.ylabel('GDP (USD Billion)')

plt.grid(True)

plt.show()
```

    iii.   Inflation Rate Trend

python
Copy code

```
inflation = [13.7, 10.8, 12.2, 8.5, 8.0, 9.0, 15.7, 16.5, 12.1, 11.4, 13.2, 16.4, 18.6, 19.5]

# Plotting Inflation Rate trend

plt.figure(figsize=(10, 5))

plt.plot(years, inflation, marker='o', color='r')

plt.title('Inflation Rate Trend in Nigeria (2010-2023)')

plt.xlabel('Year')

plt.ylabel('Inflation Rate (%)')

plt.grid(True)

plt.show()
```

    iv.   Unemployment Rate Trend

python
Copy code

```
unemployment = [6.4, 7.4, 8.2, 8.5, 7.8, 9.0, 13.4, 18.8, 23.1, 27.1, 33.3, 35.0, 33.0, 32.5]

# Plotting Unemployment Rate trend

plt.figure(figsize=(10, 5))

plt.plot(years, unemployment, marker='o', color='g')

plt.title('Unemployment Rate Trend in Nigeria (2010-2023)')

plt.xlabel('Year')
```

plt.ylabel('Unemployment Rate (%)')

plt.grid(True)

plt.show()

v.   Exchange Rate Trend

python
Copy code

exchange_rate = [150.3, 155.2, 157.5, 157.3, 168.0, 196.5, 304.3, 367.0, 361.0, 360.5, 380.0, 410.5, 440.0, 460.0]

 # Plotting Exchange Rate trend

plt.figure(figsize=(10, 5))

plt.plot(years, exchange_rate, marker='o', color='purple')

plt.title('Exchange Rate Trend in Nigeria (2010-2023)')

plt.xlabel('Year')

plt.ylabel('Exchange Rate (NGN/USD)')

plt.grid(True)

plt.show()

vi.   Foreign Direct Investment (FDI) Trend

python
Copy code

fdi = [6.1, 8.9, 7.0, 5.6, 4.7, 3.1, 4.4, 3.5, 2.2, 2.3, 2.4, 2.0, 2.5, 2.8]

 # Plotting FDI trend

plt.figure(figsize=(10, 5))

plt.plot(years, fdi, marker='o', color='orange')

plt.title('Foreign Direct Investment Trend in Nigeria (2010-2023)')

plt.xlabel('Year')

plt.ylabel('FDI (USD Billion)')

plt.grid(True)

plt.show()

vii.   Correlation Analysis

To understand the relationships between different economic indicators, we can calculate the correlation matrix.

python
Copy code

```
import seaborn as sns

# Preparing data for correlation analysis

data = {

    'GDP': gdp,

    'Inflation': inflation,

    'Unemployment': unemployment,

    'Exchange Rate': exchange_rate,

    'FDI': fdi}

df = pd.DataFrame(data, index=years)

# Correlation matrix

corr_matrix = df.corr()

# Plotting the correlation matrix

plt.figure(figsize=(10, 8))

sns.heatmap(corr_matrix, annot=True, cmap='coolwarm', linewidths=0.5)

plt.title('Correlation Matrix of Nigeria Economic Indicators (2010-2023)')

plt.show()
```

viii.   ARIMA Model for GDP Forecasting

To forecast future GDP values, we can use an ARIMA model. Below is an example of fitting an ARIMA model and making a forecast.

python
Copy code

```
from statsmodels.tsa.statespace.sarimax import SARIMAX

# GDP time series data

gdp_series = pd.Series(gdp, index=pd.date_range(start='2010', end='2023', freq='Y'))

# Fitting the ARIMA model
```

```
model = SARIMAX(gdp_series, order=(1, 1, 1))

results = model.fit()

# Making the forecast for the next 3 years

forecast = results.get_forecast(steps=3)

forecast_index = pd.date_range(start='2024', end='2026', freq='Y')

forecast_series = pd.Series(forecast.predicted_mean, index=forecast_index)

# Plotting the forecast

plt.figure(figsize=(10, 5))

plt.plot(gdp_series, label='Actual GDP')

plt.plot(forecast_series, label='Forecasted GDP', color='red')

plt.fill_between(forecast_index, forecast.conf_int()['lower GDP'], forecast.conf_int()['upper GDP'],
color='k', alpha=0.2)

plt.title('GDP Forecast for Nigeria (202
```

Discussion of Results

i.   GDP Trend Analysis

The GDP of Nigeria exhibited significant fluctuations from 2010 to 2023. The GDP growth showed an upward trend from 2010 to 2014, peaking at $568.5 billion in 2014. However, the economic recession of 2016 caused a sharp decline in GDP to $404.6 billion. Post-recession, the GDP showed gradual recovery, reaching an estimated $490 billion in 2023. This volatility can be attributed to several factors out of which are: oil price shocks, political instability, and economic policies.

ii.   Inflation Rate Trend

The inflation rate in Nigeria has been variable, with significant peaks and troughs. The rate was relatively high in the early part of the decade, peaking at 16.5% in 2017. This was largely due to the economic recession and devaluation of the naira. Although there were attempts to control inflation through monetary policies, the rate remained high, reaching an estimated 19.5% in 2023. Persistent inflationary pressures can impact purchasing power and living standards.

iii.   Unemployment Rate Trend

Unemployment has been a critical issue, showing a steady increase from 6.4% in 2010 to a peak of 35.0% in 2021. The high unemployment rate reflects structural issues in the economy, such as a mismatch between skills and job opportunities, and the impact of

economic slowdowns. Although there was a slight decrease to an estimated 32.5% in 2023, unemployment remains a major challenge.

iv. Exchange Rate Trend

The exchange rate of the naira against the US dollar has seen significant depreciation, particularly post-2014. From an average rate of NGN 150.3/USD in 2010, the naira depreciated to an estimated NGN 460.0/USD in 2023. This depreciation is attributed to various factors including lower oil prices, reduced foreign reserves, and inflationary pressures. A weaker currency can impact import costs and contribute to inflation.

v. Foreign Direct Investment (FDI) Trend

FDI inflows to Nigeria have been on a downward trend, falling from $8.9 billion in 2011 to an estimated $2.8 billion in 2023. This decline can be linked to political instability, economic uncertainty, and security issues. Lower FDI inflows can affect economic growth, as they are crucial for investment in infrastructure and job creation.

vi. Government Revenue and Expenditure

Government revenue and expenditure have shown fluctuations over the years, reflecting the volatility of oil prices and economic conditions. Government revenue dropped significantly during the 2016 recession but has gradually recovered. Expenditure has increased over time, reflecting rising costs of governance and public services. The gap between revenue and expenditure highlights the fiscal challenges faced by Nigeria.

vii. Correlation Analysis

The correlation matrix revealed significant relationships between different economic indicators:

a. GDP and Inflation: A negative correlation was observed, indicating that higher inflation rates tend to be associated with lower GDP growth.
b. GDP and Unemployment: A negative correlation was noted, suggesting that higher unemployment rates are linked with lower GDP growth.
c. Exchange Rate and Inflation: A positive correlation was observed, indicating that higher exchange rates (depreciation of naira) are associated with higher inflation.
d. FDI and GDP: A positive correlation was seen, suggesting that higher FDI inflows are associated with higher GDP growth.

The ARIMA model, after being trained and validated on Nigeria's macroeconomic indicators, will generate forecasts for key variables such as inflation, unemployment, GDP growth, and the exchange rate. These forecasts will provide critical insights into the expected future behavior of these indicators over the short to medium term. Below is an outline of how the forecasted results can inform economic policy and what actions policymakers should consider based on projected trends in inflation and unemployment.

a. Inflation Forecasts and Policy Implications

The ARIMA model's forecast for inflation may reveal trends such as:

Rising Inflation: If the forecast predicts an upward trend in inflation, this could signal potential price instability, especially in the food and energy sectors.

Stable or Declining Inflation: If inflation is forecasted to remain stable or decline, it may indicate that current monetary policies, such as interest rate adjustments by the Central Bank of Nigeria (CBN), are having a stabilizing effect.

Policy Actions for Rising Inflation:

Tightening Monetary Policy: If inflation is forecasted to rise, the CBN could respond by increasing the monetary policy rate (MPR) to curb excess liquidity in the economy. Higher interest rates will reduce consumer spending and borrowing, which can help bring inflation under control.

Strengthening the Naira: A rising inflation rate often correlates with a weakening currency. Policies aimed at stabilizing the exchange rate, such as foreign exchange interventions or promoting non-oil exports, could help control imported inflation.

Supply-Side Interventions: To mitigate inflationary pressures, especially food and energy inflation, the government could focus on increasing domestic production through subsidies or investments in agriculture and energy infrastructure. This would help reduce dependence on imports and lower cost-push inflation.

Diversifying the Economy: To reduce inflation tied to global oil price fluctuations, Nigeria could accelerate efforts to diversify the economy, investing in sectors such as manufacturing, technology, and services. Reducing reliance on oil revenues would stabilize government spending and mitigate inflationary risks.

Policy Actions for Stable or Declining Inflation:

Maintaining Current Policies: If inflation is forecasted to remain stable, policymakers could continue with current fiscal and monetary policies, but they should remain cautious of external shocks (such as global oil prices or supply chain disruptions).

Gradual Easing: If inflation is forecasted to decline to desirable levels, the government may consider easing certain monetary policies to stimulate growth without risking runaway inflation. This could involve lowering the MPR slightly to encourage investment and consumption while maintaining inflation targets.

b. Unemployment Forecasts and Policy Implications

The ARIMA forecast for unemployment could highlight different trends, such as:

Rising Unemployment: If unemployment is projected to rise, this may signal structural issues within the economy, such as insufficient job creation in key sectors or a mismatch between labor supply and demand.

Stable or Declining Unemployment: A forecast indicating stable or declining unemployment could suggest that economic growth is creating job opportunities, though this must be assessed in relation to the quality of jobs and wage growth.

Policy Actions for Rising Unemployment:

Job Creation Programs: If unemployment is forecasted to rise, the government should prioritize job creation programs, particularly in sectors with high growth potential, such as technology, agriculture, and manufacturing. Public works programs focusing on infrastructure development could also provide short-term employment while improving long-term productivity.

Skills Development and Education: Rising unemployment often reflects a mismatch between the skills of the labor force and the needs of employers. Policymakers should invest in vocational training programs, particularly in high-demand fields such as ICT, construction, and renewable energy. This would help reduce structural unemployment and ensure that the workforce is better aligned with the evolving demands of the economy.

Encouraging Entrepreneurship: Promoting small and medium-sized enterprises (SMEs) by providing better access to credit and reducing bureaucratic barriers can stimulate job creation in the private sector. Tax incentives and easier access to business capital, especially for startups, could reduce unemployment over time.

Promoting Labor-Intensive Industries: Policymakers could incentivize industries that are labor-intensive, such as agriculture, tourism, and manufacturing, to absorb a larger portion of the workforce. This would address both urban and rural unemployment, particularly among youth.

Policy Actions for Stable or Declining Unemployment:

Strengthening Labor Market Policies: If unemployment is forecasted to decline, it is crucial to ensure that the quality of jobs improves alongside the quantity. This could involve raising minimum wage standards, promoting fair labor practices, and ensuring that wage growth keeps pace with productivity.

Supporting Continued Economic Diversification: Stable or declining unemployment, coupled with consistent economic growth, should encourage policymakers to continue pursuing economic diversification. By investing in non-oil sectors, Nigeria can sustain long-term job creation and mitigate the risks associated with its dependence on global oil prices.

Incentivizing Private Sector Growth: Declining unemployment might also signal a strengthening private sector. The government can capitalize on this by further incentivizing private sector investments through tax breaks, easier regulatory frameworks, and public-private partnerships (PPPs).

c. Managing Risks Highlighted by the Forecast

The forecasts provided by the ARIMA model may highlight several risks that Nigeria's economy is likely to face in the coming years. These risks, particularly in the context of inflation and unemployment, include:

i.   **Inflationary Risks:**

Global Oil Price Shocks: Given Nigeria's dependence on oil exports, any forecast indicating rising inflation could be tied to global oil price fluctuations. To mitigate this risk, policymakers should consider building foreign exchange reserves and stabilizing the local currency to reduce exposure to external shocks.

Supply Chain Disruptions: Rising inflation may also be driven by global supply chain disruptions, particularly in the food and energy sectors. The government should enhance domestic production capacities and explore regional trade agreements that secure critical imports and exports.

ii.   **Unemployment Risks:**

Youth Unemployment: If unemployment forecasts show a rising trend, especially among youth, this could pose significant social and political risks. Policymakers should prioritize policies that target youth employment, such as entrepreneurship programs, youth-focused job training, and educational reforms aimed at equipping the young with relevant skills.

Economic Diversification: A forecast showing rising unemployment would highlight the need for continued diversification efforts to reduce dependence on oil revenues. Investing in emerging sectors such as technology, green energy and manufacturing would create sustainable jobs and drive long-term economic growth.

Forecasting

Using the ARIMA model for GDP forecasting, the GDP is projected to continue its recovery trend in the near term. The forecast for 2024-2026 suggests a gradual increase in GDP, but with wide confidence intervals, indicating uncertainties in the economic environment.

Conclusion

The analysis of Nigeria's economic data from 2010 to 2023 reveals a complex and volatile economic landscape influenced by both internal and external factors. Key challenges include high inflation, rising unemployment, currency depreciation, and declining FDI inflows.

The ARIMA model provides a mathematical framework for analyzing and forecasting time series data. By fitting an ARIMA (1, 1, 1) model to the GDP data, we can capture the underlying patterns and make informed predictions about future economic trends. The model's coefficients offer insights into the relationships between past and future values, and the forecasts help in planning and decision-making for economic policies. By addressing these challenges through informed policy decisions and strategic planning, Nigeria can aim for sustainable economic growth and improved living standards for its population. This will give the forecasted GDP values for the next 3 years along with their confidence intervals.

Nigeria Economic Data 2010 to 2023

The ARIMA model forecasts will play a critical role in informing Nigeria's economic policy by offering insights into future trends in inflation and unemployment. Policymakers must use these forecasts to develop proactive strategies to mitigate economic risks. This includes tightening or loosening monetary policy to control inflation, promoting job creation and skills development to combat rising unemployment, and ensuring economic diversification to reduce vulnerability to global shocks. By acting on these insights, Nigeria can build a more resilient and stable economy capable of sustained growth.

The ARIMA-based forecasts for Nigeria's macroeconomic indicators provide valuable insights into future trends in inflation and unemployment, both of which are critical to the country's economic stability. Based on these projections, policymakers must adopt a multifaceted approach that addresses the root causes of these issues, fosters sustainable economic growth, and protects the country from future economic shocks.

Policy Recommendations:
   a. Diversification: There is a critical need to diversify the economy away from oil dependency to more sustainable sectors such as agriculture, manufacturing, and services.
   b. Inflation Control: Implementing effective monetary policies to control inflation and stabilize the currency.
   c. Job Creation: Developing and implementing policies focused on job creation, skill development, and improving the business environment to reduce unemployment.
   d. FDI Attraction: Enhancing political stability, security, and economic policies to attract more FDI.
   e. Fiscal Discipline: Ensuring prudent fiscal management to balance government revenue and expenditure, reducing reliance on external borrowing.

Future Research:

Further research could involve more advanced econometric modeling, incorporating additional variables such as trade balances, external debts and social indicators to provide a more comprehensive understanding of Nigeria's economic dynamics. Additionally, scenario analysis and stress testing could be applied to evaluate the impact of potential economic shocks.

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