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IMPACT OF NAIRA EXCHANGE RATE VOLATILITY ON INFLATION DYNAMICS IN NIGERIA: AN ARCH-GARCH APPROACH

ABSTRACT

Unstable exchange rates and inflation can harm the economy of Nigeria; the ongoing increase in prices has made investors lose confidence in future money management plans. If inflation remains unstable for a long time and there is less investment, prices could become unbalanced in the future. As a result of this problem, this paper looks at how the naira's volatility relate to inflation, the study aims to find out which economic factors affect how much the exchange rate goes up and down in Nigeria, and also to examine the relationship between changes in currency value and rising prices in Nigeria. This study uses the GARCH model and the Vector Error Correction Model (VECM) as its main methods. The study used yearly data from the Central Bank of Nigeria and the National Bureau of Statistics from 1986 - 2023. The results from the VECM showed that the money supply (MS) and the nominal exchange rate (NER) had a positive and important impact on the inflation rate in Nigeria during the time studied. This finding means that increasing the amount of money in Nigeria can lead to higher prices, or inflation. The study thus recommends that the Central Bank should control how much money is available in the economy. This is because when there is more money available, it usually causes prices to go up (inflation). To keep inflation in check, the CBN needs to keep an eye on how much money is in circulation.

Keywords: currency devaluation, exchange rate, inflation rate, money supply, unstable prices.

JEL Classification: C22, C58, E31, F31, F41

1. Introduction

The negative effects of price rises caused by changes in currency values are a big worry for economists and decision-makers. This has raised many questions and interest among economists about why this instability is happening, especially in our floating exchange rate system. The connection between inflation and exchange rates, and how a drop in the exchange rate can lead to an increase, and the other way around, usually happens without the government trying to change anything. This process is influenced by several factors: the type of exchange rate system in the country, the government's economic goals, how open the economy is to trade, and how easily money can move in and out of the economy.

The way a country sets its exchange rate is important for lowering the risk of changes in the actual exchange rate, which can influence inflation rates and the other way around (CBN Statistical Bulletin, 2019).

Nigeria's economy grew slowly in 2022, increasing by less than 3.3%. This is lower than most other countries in West Africa. For example, Niger grew by 9.4%, Senegal by 7.7%, Togo by 6.4%, Benin by 6.1%, and Mali by 5.2%. Nigeria's economy did not do well in 2022 because people were not spending money and businesses were not investing. This was caused by ongoing problems with currency value and high prices. For example, inflation started at 13.7% in 2010, went up to 15.6% in 2016, and reached 18.8%. The decrease in private spending shows that strict money policies and higher prices for basic goods hurt how much money families have to spend. The AFDB (2023) mentioned that inflation is expected to decrease a lot in all areas. However, the ongoing problems in Nigeria are likely to hurt economic growth for a long time.

Nigeria depends too much on food and energy from other countries, and the US dollar is getting stronger compared to the Naira. This has made it harder to get enough money and has caused the Naira to lose value quickly (Calderon et al., 2022). The fast rise in food and energy prices around the world is caused by higher insecurity, wars, ongoing conflicts between herders and farmers that limit food supply, and many climate-related disasters that negatively affect food production. High inflation is a problem that slows down the economy, growth, and progress in developing countries like Nigeria.

The International Monetary Fund (IMF) (2019) asserted that the ongoing increase in prices has made investors lose confidence in future money management plans. When the value of money goes up, it makes imported goods cheaper and may help lower prices overall. However, if inflation remains unstable for a long time and there is less investment, prices could become unbalanced in the future. Nigeria has a fixed exchange rate system. This means the Central Bank buys and sells currency to keep the supply and demand for money in balance. Nigeria has been pushing for the use of important foreign money like the US Dollar, the British Pound, and the Euro. This has resulted in more people wanting these currencies than are available. Because of this, the naira loses value while the main foreign currencies gain value. Additionally, depending too much on foreign products, education, and technology can lead to changes in currency value (Akpan & Udo, 2023). Also, the country's money has been facing challenges because of changes in the economy, a lack of foreign currency, and tougher rules for banks. This has also made trading money with other countries more unstable. Economic theory suggests that studying the relationship between exchange rates and inflation can help understand how a stable exchange rate might lower inflation (Şen et al., 2020).

Babatunde and Kehinde (2016) said that when exchange rates change a lot, inflation will be high. This means that changes in exchange rates can cause prices to go up in an economy. He said that if prices keep changing a lot, it can make the market more risky and uncertain. A policy for price stability aims to keep money's value steady and avoid big ups and downs in the economy. Changes in local prices reduce the worth of money as a way to save, and make businesses less certain and more risky. Okwori and Abu (2017) suggested that to fight inflation and keep prices steady, Nigeria has used direct ways of

managing money, like controlling which loans are given, setting interest and exchange rates, limiting the amount of credit available, requiring banks to keep extra cash, and creating special deposits.

In economic studies, the results about how inflation and changing exchange rates affect the economy have been varied. So far, people don't agree on the relationship between the naira's volatility and inflation. This is important because unstable exchange rates and inflation can harm the economies of developing countries, especially those in Africa. This paper aims to look at how the ups and downs of the naira relate to inflation. This study uses the GARCH model and the Vector Error Correction Model (VECM) as its main methods. The study used yearly data from the Central Bank of Nigeria and the National Bureau of Statistics from 2023. The study also discusses suggestions to improve the links between the exchange rate, inflation rate, and economic growth. The main objective of this study is to find out the impact of naira's volatility on inflation. Other objective of the study are to: examine the relationship between changes in currency value and rising prices in Nigeria.

2. Literature Review

2.1 Conceptual Issues

2.1.1 Exchange Rate

The exchange rate is how much one country's money is worth compared to another country's money. For example, the Nigerian Naira is worth a certain amount when compared to the U.S dollar and a lot of other money types. It can be called either the nominal exchange rate or the real exchange rate. Akintola and Lawal (2012) say that the nominal exchange rate is a way to compare the values of two currencies. The Naira compared to the dollar (N/\$) shows how much one currency is worth against the other. The real exchange rate is a measure that looks at how much products from different countries cost relative to each other.

The nominal exchange rate in this study refers to how many Naira you get for one dollar. This measurement matches what other studies on exchange rates have found, like those by Yaqub (2010) and Iyeli and Utting (2017).

2.1.2 Volatility

Volatility shows how quickly and by how much prices go up and down from a trend. In simpler terms, it shows how much the real price is different from what we would normally expect it to be. Calculating and estimating price changes is not just about exchange rates; it is talked about a lot in many areas of economics. Previous studies about volatility mainly looked at how the value of investments or financial assets changes.

In general, ways to measure changes in exchange rates can be grouped into two main types (Matthews, 2010). First, understood historical volatility, which looks at how much past prices have changed. Secondly, stochastic volatility measures how much the price of something can change at a certain moment while also taking into account how much it has changed in the past. So, in simple terms, volatility here means how quickly the exchange rate goes up or down over a certain time (Kashif et al.

2010). It is figured out by calculating how much the yearly returns vary over a certain period. In financial markets, we measure how much the price of an asset can change by looking at the standard deviation of its returns. This measure is important in option pricing formulas, as it shows how much the price of the asset is expected to change from now until the option expires (Shiller and Radikoko, 2014).

In this study, we measure volatility by looking at how it tends to group together over time. This method used the GARCH model, which stands for Generalized Auto-Regressive Conditional Heteroscedasticity. This measurement matches findings from other studies about how much exchange rates change, like the one by Tarawalie et al. (2012). Exchange rate volatility means that exchange rates can change suddenly and unpredictably. Based on what Yakub et al. (2019) said exchange rate volatility means that the value of a country's money can go up or down over time. The exchange rate is how much one country's money is worth compared to another country's money.

2.1.3 Inflation

Inflation means that the prices of things we buy usually go up over time. Inflation has big effects on how money works for buying things and saving value. Chukwuemeka (2018) described inflation as a continuous increase in the overall prices. Inflation is when prices for things keep going up in a country. Inflation is when prices in an economy keep going up over time. A price increase alone doesn't always mean inflation. For it to be called inflation, prices need to go up everywhere in the economy, and this increase has to keep happening over time.

Inflation can be divided into two kinds: creeping inflation and hyperinflation. Creeping inflation means that prices slowly go up over a long time. In other words, prices are going up slowly and steadily for a long time. It will keep getting worse slowly but surely.

Hyperinflation, also known as "runaway" or "galloping" inflation, is when prices go up very quickly and by a lot, sometimes by 50% or more each month. Hyperinflation can quickly reduce the value of a country's money and make people lose faith in it. Hyperinflation happens when prices go up very quickly, often by 100% or more. In this situation, the inflation rate becomes completely out of control. Prices usually go up quickly and can double several times in a single day. This situation causes the money system to totally fail because money keeps losing its value. Hyper-inflation, unlike slow inflation, usually happens for a short time. The consumer price index helps track how much prices go up over time. The consumer price index (CPI) tracks how prices of goods and services change over time.

2.1.4 Exchange Rate Volatility and its Effect on Inflation in Nigeria (Jan 2024 – April 2024)

Most currencies in sub-Saharan Africa have lost value compared to the US dollar, making inflation worse as the cost of imports rises sharply. This, along with a slowing economy, puts policymakers in a tough spot as they try to control inflation while also helping the weak economic recovery.

Exchange rate policies in developing countries can cause strong feelings and debates because they involve big changes to the economy. These changes usually mean buying less from other countries or

selling more things (that aren't oil) to other countries. This often causes the value of the currency to go down. These changes at home are considered bad for the economy because they quickly affect prices and how much people want to buy. It's interesting that countries with developing economies, which depend on imports for making things and buying goods, don't often talk about the problems caused by having a currency that is worth too much. Many people agree that lowering the value of a currency can boost local production by making exports more appealing. It is believed that as local industries become more competitive, people will start buying less expensive home-made products instead of pricey foreign ones.

However, this is often not true in Nigeria, where people still really want foreign products. In Nigeria, exchange rates greatly affect foreign travel, payments for imports, money sent back home from abroad, and the everyday prices of goods. The economy is being impacted by the drop in the value of the naira, affecting trade, money movement, prices, and interest rates. This is happening after the economy started to recover from changes made to the naira in February 2023. Things happening outside Nigeria, like less willingness to take risks in global markets, higher interest rates in the United States, a fall in money coming in from foreign exchange, and a big budget deficit, could lead to the decrease in Nigeria's value.

In the first part of 2024, the naira's value changed a lot and dropped compared to the USD. This caused economic uncertainty, difficulties for businesses, and quick changes in the prices of goods. In the first three months, the price of food went up quickly along with the value of the US dollar. In January 2024, the exchange rate was about N942 for every US dollar, and food prices were rising at a rate of 35.41%. The exchange rate was highest in March, averaging N1,507 for every dollar, and food prices went up by 40%, which is the highest ever. This means that food prices went up a lot because the exchange rate increased, making it harder for people to buy things since the minimum wage stayed the same at N30,000.

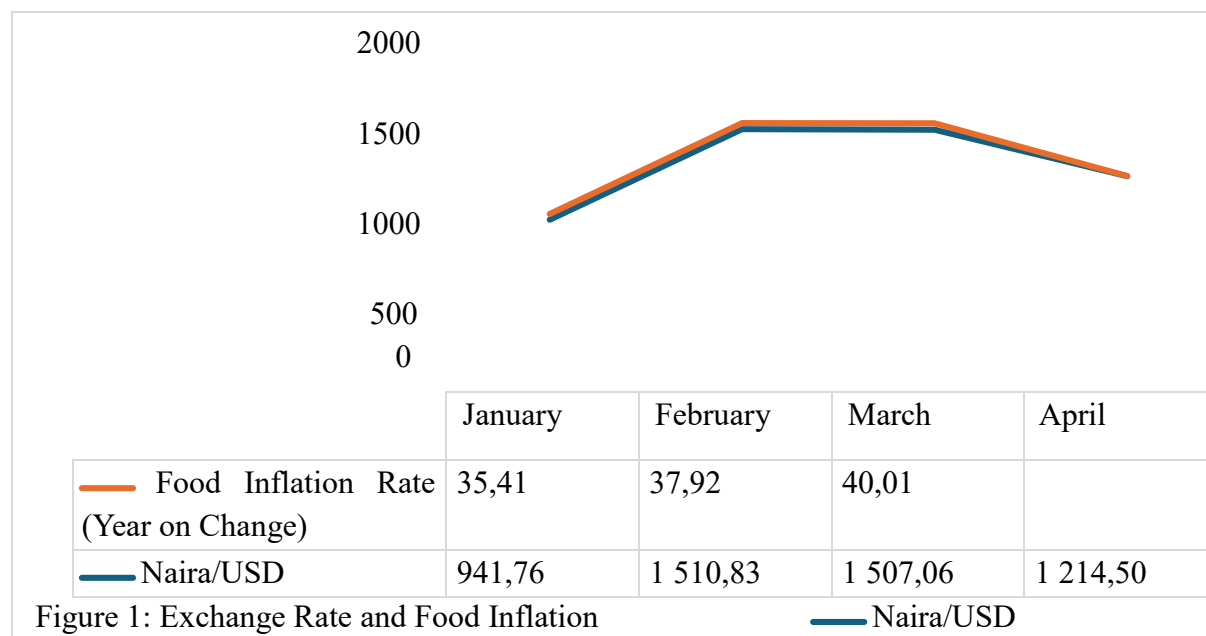


Figure 1: Exchange Rate and Food Inflation
Source: Computed from Data on CBN Database (2024)

At the small-scale level, food prices have gone up along with the dollar. For example, in January, the price of one mudu (0.66kg) of rice was about N1,700, beans N1,200, sugar N1,900, and a loaf of bread N1,000. By April, these prices rose to around N2,400 for rice, N1,800 for beans, N2,800 for sugar, and N1,400 for bread. This means that the prices of rice, beans, sugar, and a loaf of bread have gone up by 27%, 33%, 32%, and 28%, respectively. Figure 2 shows that the exchange rate went down by 24% from March to April 2024. At the same time, food prices kept going up. The price of one mudu (0.66 kg) of rice increased by 12%, one mudu of beans went up by 9%, and one mudu of sugar rose by 6%. This means that other things, like the cost of diesel, the road system, and customs fees, also played a part in the price going up. Figure 3 shows that diesel prices went up by 15%, rising from N1,153 in January to N1,350 in April 2024. Diesel prices affect how much it costs to make and transport goods, which in turn influences what people pay for those goods.

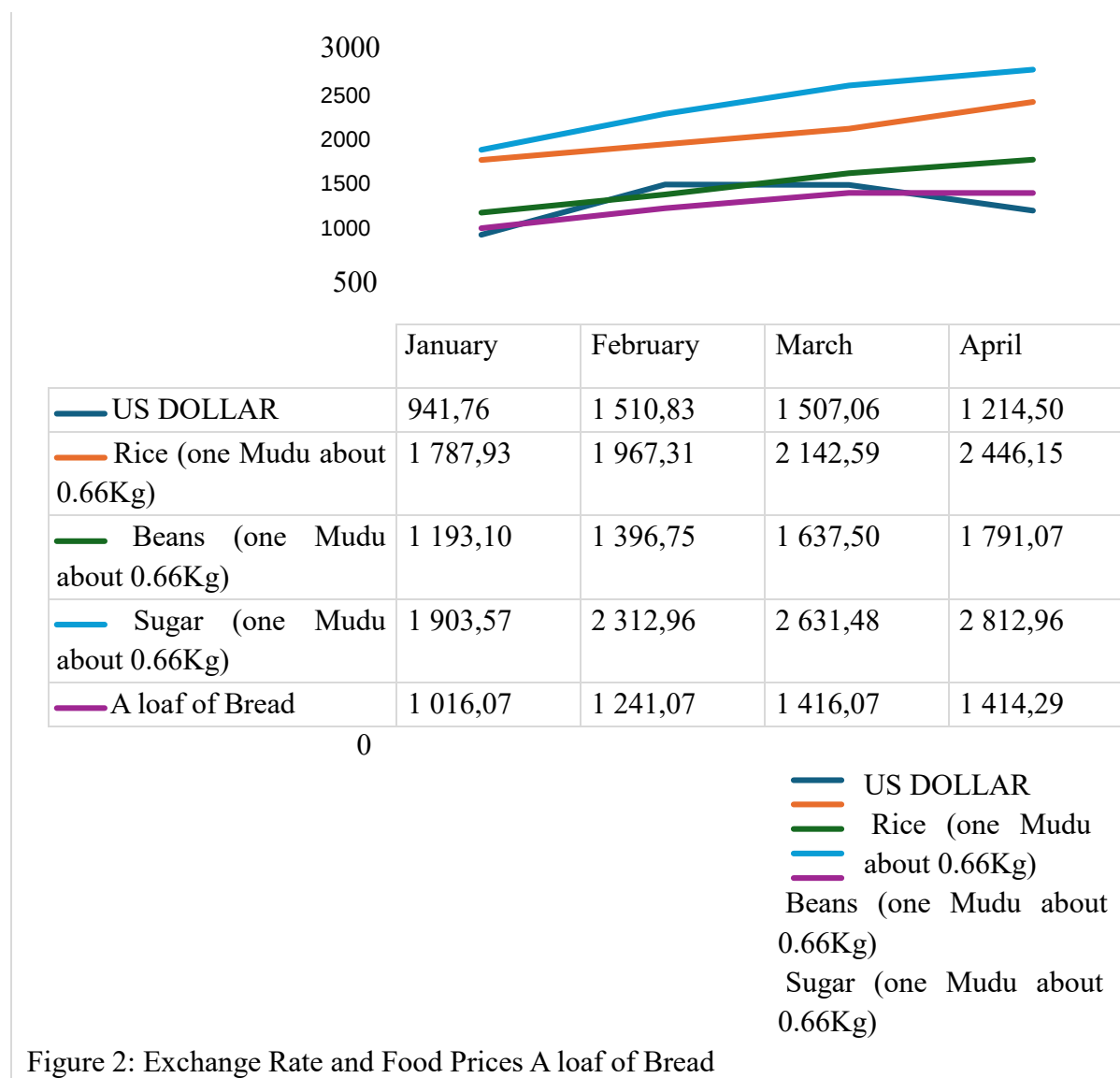


Figure 2: Exchange Rate and Food Prices A loaf of Bread

Source: Computed from Data on CBN Database (2024)

Many things have caused the ups and downs in Nigeria's exchange rate, such as dropping oil prices, using up foreign exchange reserves, and money leaving the country. The Nigerian government and central bank have taken different steps to make the currency stable and increase foreign money reserves. These actions involve changing currency policies and trying to reduce reliance on oil by developing other parts of the economy.

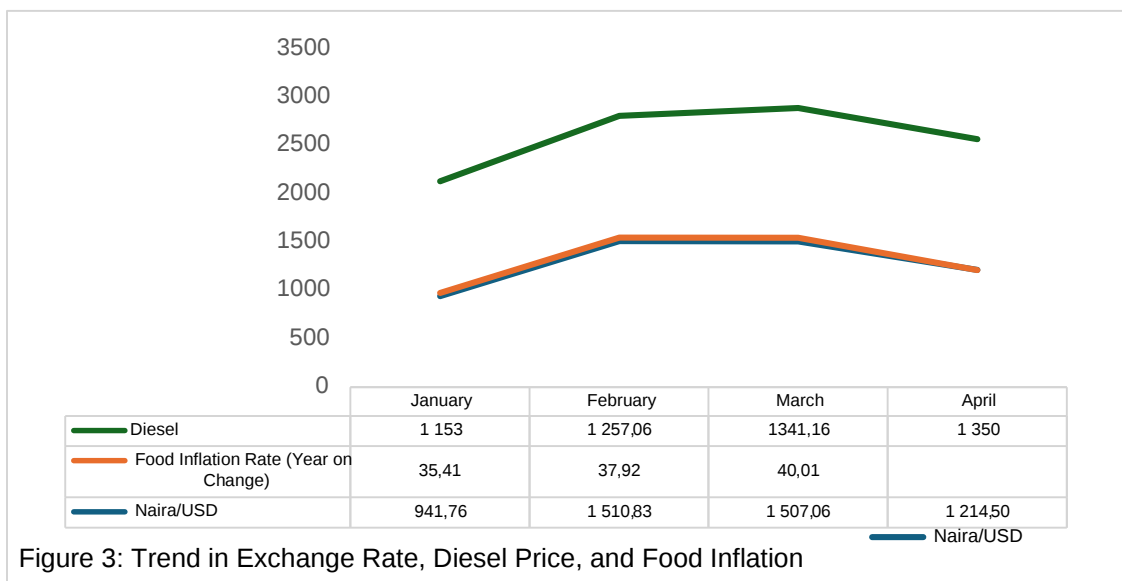
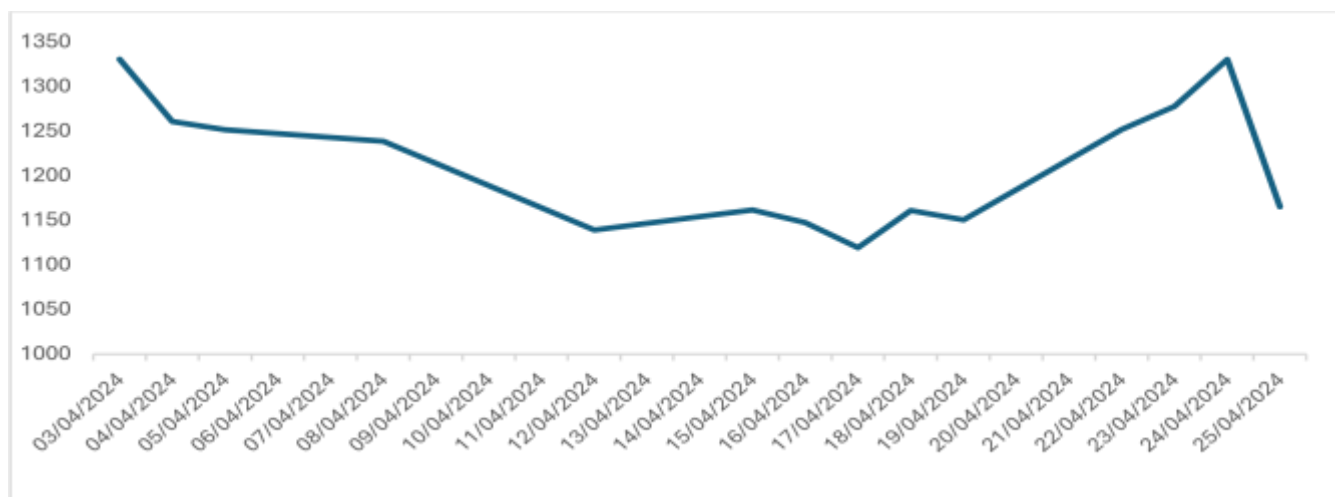


Figure 3: Trend in Exchange Rate, Diesel Price, and Food Inflation

Source: Computed from Data on CBN Database (2024)

Different policies that were put in place during the time we looked at seemed to have had some effect, as the exchange started to decrease but then went back up again (Figure 4). In April, the value of the naira went up compared to the dollar. It increased by more than 31%, rising from a high of about N1,662 for \$1 in February to around N1,150 for \$1 in April 2024. As the naira gets stronger, people in Nigeria hope that food and essential items will become cheaper, but prices are still high. Even though the Naira has gotten stronger, Nigeria's inflation rate went up to 33.20% in March 2024. This is higher than the inflation rate of 31.70% in February 2024, which is an increase of 1.5%.



Figure

4: Trend in Exchange Rate April 2024

Source: Computed from Data on CBN Database (2024)

Banks and financial institutions in Nigeria are also affected by changes in exchange rates and how those changes impact the economy. When exchange rates go up, it raises production costs and prices of goods. This leads to more people seeking loans from banks, which affects how well banks perform. It also makes the economy less certain, increases the difference in loan interest rates, and raises the number of loans that aren't being paid back. Changes in exchange rates can directly influence how well banks do because they deal with foreign currencies. This also affects how people who save money in banks and those who borrow money behave. Overall, it can lead to more risks and lower performance for banks. Additionally, rising prices will impact contracts that were given out before the Naira lost value, which will affect how long it takes to finish the work and increase production costs. Investors might be discouraged from putting their money into banks because the economy is uncertain.

2.2 Theoretical Review

In 1938, Fisher said in his Quantity Theory of Money that exchange rates are set when the amount of money people want to use balances with the amount of money available in each economy. The monetary approach says that over the long term, the amount of money people want to hold stays steady. It goes up when national income (the total money made by a country) increases and goes down when interest rates rise. The amount of money in the country is its basic money times a number that shows how much that money can grow. The country's money supply is made up of the loans created by its central bank plus the money it has saved from other countries. If people in the country aren't spending enough money, having too much money can lead to problems. It can cause the country to lose its reserves and create a deficit in its balance of payments when exchange rates are fixed. If the exchange rate is flexible, the currency can lose value instead. The opposite happens when there is too much demand for money in the country.

This theory looks at how much currency is available and how ready people are to keep that currency. The monetary theory says that exchange rates change so that the amount of money in each currency that people want to buy is equal to what is available (Rasaq, 2012). Both the Quantity Theory of Money (QTM) and Purchasing Power Parity (PPP) have been used to support this theory.

Fisher's Quantity Theory of Money says that as the amount of money in an economy increases, the prices of goods and services also go up. In simple terms, if there is more money, prices go up. In a home setting, the equation below is created to show how money supply affects inflation:

$$MV = PY \quad (2.1)$$

M = Money supply/demand; V = Velocity of circulation (the number of times money change hands); P = Average price levels; Y = Output (GDP)

In the end, we can say that when there is more money available, it causes prices to go up (inflation), which makes money worth less and reduces how much you can buy with it. In the same way, if we look at this globally, the following points will apply:

First, when the amount of money in the country quickly goes up, it leads to inflation. This will cause the purchasing power parity (PPP) to take effect, which means the value of the currency will decrease in exchange rates. Secondly, higher interest rates will cause the currency to lose value because when interest rates go up, more money is in circulation.

Finally, if the economy at home grows faster than the economy in other countries, people will want more money. If there is a certain amount of money available, the exchange rate will go down.

2.3 Empirical Review

Ribeiro et al. (2019) looked at how the real exchange rate affects economic growth in 54 developing countries using data from 1990 to 2010. They found out that low value had a negative effect on economic growth in developing countries. Karahan's (2020) study found similar results about how exchange rates relate to economic growth in Turkey. The paper used quarterly data from the years 2002 to 2019. The study found that when exchange rates go up, economic growth goes down. This means that higher exchange rates are linked to lower production levels. The report says we should work to keep prices and exchange rates steady to control inflation. Idris and Suleiman (2019) studied how inflation affected Nigeria's economic growth from 1980 to 2017. The study examines certain factors using a method called vector error correction. The findings indicate that these factors have a major negative effect on Nigeria's economic growth over the long run.

Recent research by Amor et al (2023) looked at how problems with Tunisia's currency value affected its economy. From 2001 to 2016, Tunisia had times when its currency was worth too much and times when it was worth too little. When the value of the currency was too high, it harmed Tunisia's economy. But when the currency was undervalued, it didn't really affect the economy much. The limit for how the real exchange rate misalignment affects growth is important because a lower real value can help growth,

but only up to about 10.02% away from the ideal value. Najafi et al. (2023) looked at information from Iran, Iraq, and Turkey from the years 2005 to 2020, it was found that inflation hurt the economic output of countries, but the exchange rate didn't seem to have any noticeable impact. Most studies show that when inflation goes up, people have less money to spend. This problem affects the most vulnerable people the most. It is suggested to lower the inflation rate from over 10% to below 10% to boost investment. Adaramola and Dada (2020) use a statistical method called autoregressive distributed lag to study how inflation, interest rates, exchange rates, the openness of the economy, money supply, and government spending affect the real gross domestic product (GDP) from 1980 to 2018. The study found that rising prices and changes in currency value slow down economic growth. The paper suggests that money officials should work harder to control inflation. This will help avoid negative effects and keep inflation at a manageable level to help boost the economy.

Gregorio (2021) studied how inflation and growth rates are connected in a group of Latin American countries. Money and resources have been redirected from projects that help the economy grow faster to ones that focus on reducing inflation costs. This has caused growth to slow down. A study looks at several Latin American countries to see how inflation is related to economic growth, finding that when inflation goes up, growth tends to go down. Tarawalie and Kamara (2022) use a curved model (quadratic function) in Sierra Leone. They looked at data from 1980 to 2020 to understand how inflation and economic growth are related, using a straightforward analysis method. They came to a simple conclusion. The results show that the connection between inflation and growth is not straight or direct. The results show that a 10.3% inflation rate is the best level for helping the economy grow. In Sierra Leone, when inflation is below 10.3%, it helps the economy grow. But when inflation goes above 10.3%, it hurts the economy. Azam and Khan (2022) looked at how inflation affects economic growth in 27 countries, which include 16 developing countries and 11 developed countries, over the years 1975 to 2018. Their results show a strong negative connection between inflation and growth when inflation is higher than a certain level. Based on research, inflation causes the most harm in rich countries when it hits a certain level, which is 12.23% in poorer countries and 5.36% in richer countries.

Asteriou et al (2016) looked at how changes in exchange rates affected international trade in Mexico, Indonesia, Nigeria, and Turkey. They used special methods called GARCH and ARDL to do their analysis. They did not find any lasting connection between changes in exchange rates and the amount of international trade in those countries, except for Turkey, where the changes were very small. They found that, in the short term, changes in exchange rates strongly affected the amount of exports and imports in Indonesia and Mexico. They also discovered that in Nigeria, the demand for exports influenced the changes in the value of the Naira compared to the Dollar.

Safuan (2017) studied how changes in exchange rates affected exports to the United States, Japan, and China from 1996 to 2016. He used a method called unrelated regression and found that fluctuations in exchange rates hurt the amount of exports. When they broke down the data, it showed that the changes in the exchange rate had a negative effect on exports and this varied by industry in the countries they studied. Alper (2017) studied how changes in exchange rates affected Turkey's trade with fifteen

European countries from early 1971 to late 2015. He used a special model called GARCH. The findings showed that when exchange rates were unpredictable, Turkey's exports decreased in the short term, but the effects on imports over a longer period were not clear. He then decided that changes in exchange rates did not impact the amount of trade between Turkey and European countries.

Bahmani-Oskooee and Gelan (2018) studied how changes in currency values affect trade in twelve African countries from the first quarter of 1971 to the fourth quarter of 2015. They used a method called the ARDL model for their analysis. The results showed that there is a lasting connection between changes in exchange rates and trade in all the chosen countries. Latief and Lefen (2018) studied how changes in exchange rates affected international trade and foreign investment from 1995 to 2016 in seven developing countries: Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. They used a method called the GARCH model for their analysis. They found that changes in the exchange rate helped international trade for Bhutan, Maldives, and Nepal, but had bad effects for Pakistan and Sri Lanka. The study found that, using the TGARCH model, changes in exchange rates significantly affect international trade for Bhutan, Maldives, and Nepal. In India and Pakistan, foreign direct investment and changes in currency values often go well together. However, in Bhutan and Nepal, they do not. Muhia and Gachunga (2019) looked at how changes in exchange rates affected exports and imports in Kenya from 1980 to 2015. They used a specific mathematical method and found a strong connection between exchange rate changes and trade.

In a study about Vietnam, Thuy and Thuy (2019) found that changes in the exchange rate hurt export amounts over a long period. They also discovered that when the currency loses value, it hurts exports in the short term but helps them in the long term. This shows the J-curve effect in Vietnam. Also, when foreign incomes go up, it leads to a drop in the amount of goods Vietnam exports. Bostan and Firtescu (2019) used a method called Ordinary Least Squares (OLS) to study data about Romania. The results showed that changes in the exchange rate are important for competitiveness. However, the impact of the uncertainty from these changes is not strong for imports but is strong for exports.

Ikechi and Anthony (2020) looked at how changes in currency value affected trade in Nigeria from 1996 to 2018. They used a method called vector autoregression (VAR) and found that when the real effective exchange rate (REER) was unstable, both exports and imports decreased. The variance decomposition showed that some of the changes in exports, imports, and real effective exchange rates were due to shocks. The study showed that imports can lead to increases in exports, but exports do not lead to increases in imports. The GARCH results also show that there is fluctuation in the real effective exchange rate (REER) affecting exports and imports in Nigeria. In a related study about how oil price changes affect exchange rates in Nigeria, Tule and Osude (2014) looked at monthly data from 2000 to 2013. They used special methods called GARCH and EGARCH to show a strong link between changes in oil prices and the real exchange rate in Nigeria.

Achouak, Ousama, and Mourad (2018) looked at how changes in exchange rates affect economic growth in 45 developing and emerging countries from 1985 to 2015. The study used a GARCH model to analyze the data. The findings showed that changes in both nominal and real exchange rates hurt economic

growth. Zidek and Suterova (2017) looked at how changes in currency values affect inflation in Switzerland. The study used data from every three months, covering the time from the first quarter of 2000 to the fourth quarter of 2016, which was obtained from the European Central Bank. The study used a method called Structural Vector Auto regressive (SVAR) to analyze the data. The study showed that changes in the exchange rate led to higher prices in the area.

Viola, Klotzle, Pinto, and Gaglianone (2017) studied how changes in exchange rates affect inflation in Brazil. They used yearly data from the Central Bank of Brazil, covering the years 1980 to 2015. To measure how much something changes over time, the study used two models: GARCH (1,1) and EGARCH (1,1). The study found that both GARCH (1,1) and EGARCH (1,1) models showed that changes in the exchange rate tend to continue over time. Serenis and Tsounis (2014) studied how changes in currency values affected the total exports of two small countries, Croatia and Cyprus, by looking at data from 1990 to 2012. The Autoregressive Distributed Lag (ARDL) model was used for the analysis, and the results showed that changes in exchange rates had a strong positive effect on the exports of Croatia and Cyprus.

Vieira, Holland, Gomes, and Bottecchia (2013) studied how changes in exchange rates affect economic growth. They looked at data from 82 developed and emerging countries from 1970 to 2009. The study used a method called GARCH to analyze the data. The findings showed that changes in both the nominal and real exchange rates hurt economic growth in the countries studied. Also, Mori, Rozilee, Jarati, Dullah, and Nanthakumar (2012) looked into how changes in the exchange rate affected economic growth in Malaysia from 1971 to 2009. The variables used are GDP, real exchange rate, and nominal exchange rate. The study used a method called Autoregressive Distributed Lag for the analysis. The results showed that both types of exchange rates (nominal and real) positively and significantly helped economic growth in Malaysia.

Nkoro and Uko (2016) studied how changes in exchange rates affect inflation in Nigeria. They used data collected every three months from 1986 to the end of 2012, which they obtained from the Central Bank of Nigeria's Statistical Bulletin and the National Bureau of Statistics. The study used a GARCH model. The study found that both the exchange rate and inflation rate in Nigeria are constantly changing. Obiekwe and Osabunhien (2016) looked at how changes in exchange rates impact inflation in Nigeria by studying yearly data from 2006 to 2015. The study used the GARCH method to check for changes in the exchange rate in Nigeria. The study used the ARCH model in its analysis. The results showed that changes in the exchange rate greatly affected the inflation rate in Nigeria.

Also, Ajao and Igbekoyi (2013) studied the factors that cause changes in the real exchange rate in Nigeria by looking at yearly data from 1981 to 2008. Using GARCH methods and the Error Correction Model (ECM), the study found that trade openness, government spending, interest rates, and past exchange rates all positively and significantly affected the ups and downs of the real exchange rate during the time studied. Dickson and Andrew (2013) studied how changes in exchange rates affected trade in Nigeria from 1970 to 2010. The study used the error correction and GARCH model for its

analysis. The results showed that changes in the exchange rate did not have a big impact on imports, but they did have a positive and important effect on exports.

The reviews show that there aren't many studies looking at how changes in naira's volatility affect inflation in Nigeria. This study is one of the few that has looked at how changes in exchange rates affect inflation in Nigeria. This study adds to the existing research by using different methods, different factors, and a broader range for the study. Unlike earlier studies that looked at how much exchange rates change over time using standard deviation (Achouak et al., 2018; Viola et al., 2017), this study takes a new approach by measuring volatility with a method called generalized autoregressive conditional heteroskedasticity (GARCH). This is an important gap that this research aims to fill.

3. Methodology

The methodological framework for this study is based on the Generalised Autoregressive Conditional Heteroscedasticity (GARCH) model proposed by Bollerslev (1986) and Vector Error Correction Model (VECM) developed by Johansen and Juselius (1990) and Johansen (1991) for the analysis. The study used annual time series data sourced from Central Bank of Nigeria (2023) and National Bureau of Statistics (2023).

3.1. Model Specification

This study used two methods, the GARCH model and the Vector Error Correction Model, to look at how changes in exchange rates affect inflation in Nigeria. We chose this model because it shows how changes in the exchange rate affect things in both the short term and the long term.

This study used and changed the research done by scholars such as Obiekwe and Osabunhien (2016) and Achouak et al. (2018), used the GARCH and ARDL models in their study. The factors used in this study are the consumer price index (CPI), nominal exchange rate (NER), money supply (MS), imports (IMP), and exports (EPT).

The specification of the conditional variance in a GARCH model is as shown in Equation 3.1

$$\lambda_t = \phi_0 + \sum_i \beta_i Y_{t-i} + \sum_j \alpha_j \varepsilon_{t-j} \quad [3.1]$$

where λ_t represents the exogenous variables, $\phi > 0$ to warrant that λ_t is a positive variance.

The general form of VECM model adopted for the study is specified as in Equation 3.2

$$\Delta \ln Y_t = \alpha_{0y} + \sum_i^n \alpha_{yi} \Delta \ln Y_{t-i} + \sum_i^n \alpha_{yi} \Delta \ln Y_{it-1} + \delta_1 \ln X_{it-1} + \delta_2 \ln X_{it-1} + \mu_t \quad [3.2]$$

where Δ is first difference operator, y_t is the dependent variable, which is a function of its lagged values as well as the lagged values of the independent variables, δ denotes the coefficients of the short run dynamics, μ_t is the error term.

The mathematical form of the model is specified as in Equation 3.3

$$CPI = f(IMP, EPT, MS, NER) \quad [3.3]$$

The econometric form of the model is specified as in Equation 3.4

$$CPI = \delta_0 + \delta_1 IMP + \delta_2 EPT + \delta_3 MS + \delta_4 NER + u \quad [3.4]$$

$$\begin{aligned} LnCPI = \delta_0 + \delta_1 LnIMP_{t-1} + \delta_2 LnEPT_{t-1} + \delta_3 LnMS_{t-1} + \delta_4 LnNER_{t-1} \\ + ECM_{t-1} + U_t \end{aligned} \quad [3.5]$$

where; CPI represents consumer price index which is used as the dependent variable while the independent variables are import (IMP), export (EPT), money supply (MS) and nominal exchange rate (NER). δ_0 is the intercept while $\delta_1 - \delta_4$ are the coefficients of the independent variables. All the variables for estimation in Equation 9 are expressed in their natural logarithmic function denoted by ln in the model. ECM_{t-1} represents one period lagged error correction term and U_t denotes error term.

3.2. A Priori Expectation

On a priori ground, we expect the value of $\delta_1 - \delta_4$ to be positive and greater than zero.

4. Results and Discussion

4.1. Test for Volatility

We used the GARCH model to check how much the real exchange rate changes. The results of the volatility test are shown in Table 1.

Table 1: Results of volatility test.

	Coefficient	Std. Error	z-Statistic	Prob.
C	1.05E+08	70338721	1.486582	0.1371
ARCH(1)	-1.043886	0.058413	-17.87068	0.0020
GARCH(1)	0.554921	0.094078	5.898532	0.0065

The results of the volatility test shown in table 1 indicate that the GARCH(1) coefficient (0.554) is important at a 5% significance level. This means that changes in the real exchange rate, measured by the GARCH model, have a strong and positive impact on inflation in Nigeria, according to the z-statistic. This result agrees with research done by Nkoro and Uko (2016), which found that changes in exchange rates have a positive and important impact on inflation in Nigeria.

4.2. Test for Stationarity

The Augmented Dickey Fuller (ADF) test was done to find out the order of integration. The results of the stationarity test are shown in Table 2.

Table 2: Stationarity Test Results.

At levels	At 1 st difference
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Variables	ADF statistics	Critical value at 5%	ADF statistics	critical value at 5%	order of integration	Decision
LCPI	-2.789	-2.960	-4.336	-2.960	1(1)	Stationary
LIMP	-2.432	-2.957	-7.512	-2.960	1(1)	Stationary
LEPT	-2.467	-2.971	-3.286	-2.986	1(1)	Stationary
LMS	-0.651	-2.957	-5.282	-2.960	1(1)	Stationary
LNER	-2.607	-2.857	-4.380	-2.960	1(1)	Stationary

The results from the stationarity test in table 2 shows that, at a 5% significance level, all the series (CPI, IMP, EPT, MS, NER) are stable after taking the first difference, labeled as 1(1). Since all the variables stay at the same level and are integrated of order one (I(1)), this supports using a vector error correction model (VECM). So, having a unit root in the data means we should do a co-integration test.

4.3. Co-Integration Test

To find out if there is a long-term relationship between the variables, this study used the Johansen co-integration test, and the results are shown in Table 3.

Table 3: Co-integration test results

No. of CE(s)	λ Trace	5%	λ max	5%
None *	68.25142	52.82613	48.40240	25.53436
At most 1	19.86882	27.79707	12.77607	21.13167
At most 2	7.092747	15.49471	7.525621	14.26460
At most 3	0.567126	3.841466	2.567126	3.841466

Note: Trace test indicates 1 cointegrating eqn(s) at the 0.05 level. Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level. λ_{Trace} = Trace Statistic,; λ_{max} = Maximum eigenvalue.

The results from the Johansen cointegration test in table 3 show that there is a long-term relationship between the variables in the model. This is supported by both the trace test and the maximum eigenvalue test, which show that there is 1 cointegrating equation at the 0.05 level. These results show that the factors have a long-term connection. After figuring out that the variables are related over a long time, the next step was to calculate the long-term results.

Table-4: Long-run static regression results.

Dependent variable is LnCPI

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.078473	0.022997	46.89546	0.0000
LnIMP	-2.869965	0.856351	-3.351388	0.0032
LnEPT	0.086437	0.043051	2.007793	0.0556
LnMS	0.474455	0.202164	2.346885	0.0268
LnNER	1.646799	0.774260	2.126934	0.0461
R-squared	0.770711	F-statistic		13.44527
Adjusted R-squared	0.713389	Prob(F-statistic)		0.000000
Durbin-Watson stat	2.082624			

The results in Table 4 show that the exchange rate has a positive and strong effect on inflation in Nigeria. This means changes in the exchange rate can impact inflation levels. This matches what we expected beforehand. This finding agrees with research done by Obiekwe and Osabunhien (2016), which found a strong link between changes in exchange rates and inflation rates in Nigeria.

The analysis shows that imports have a bad and important impact on inflation in Nigeria. This negative number shows that Nigeria relies a lot on imports. This means importing too many goods is bad for the economy's growth and is also causing prices to rise.

The result also shows that exports positively and strongly affect economic growth. The EPT number is 0.086437, and the chance of it happening is 0.0556. This matches what we expected before. The result also shows that there is a strong and positive connection between the amount of money available and inflation. The MS value is 0.474455, and the chance of something happening is 0.0268. This regression coefficient is positive and important, as indicated by the probability value. This means that if MS goes up by 1 unit, inflation will increase by about 0.47 units. This matches what we expected.

The R-square value shows that about 0.77% of the total changes in the dependent variable can be explained by changes in the other variables. So, the regression works well.

The F-statistic (13.4) shows that all the variables are important together at a 5 percent level because the probability value is very low at 0.0000. The Durbin-Watson number of 2.08 shows there is no autocorrelation in the estimate.

After looking at the long-term effects, the next step was to examine how the independent variables affect the dependent variable in the short term. The short-term results are shown in Table 5.

Table-5: Dynamic short-run results.Dependent variable is *LnCPI*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.078473	0.022997	46.89546	0.0000
D(CPI(-1))	3.671029	1.036226	3.542690	0.0015
D(IMP(-1))	-0.392764	0.163190	-2.406790	0.0227
D(EPT(-1))	0.555476	0.281356	1.974282	0.0591
D(MS(-1))	1.652275	0.631799	2.615190	0.0181
D(NER(-1))	2.230552	0.681695	3.272069	0.0045
ECM(-1)	-2.163624	0.444934	-4.862798	0.0001
R-squared	0.730452	F-statistic		53.78871
Adjusted R-squared	0.681444	Prob(F-statistic)		0.000000
Durbin-Watson stat	2.023522			

The short-term results shown in Table 5 suggest that the past values of EPT, MS, and NER have a strong and positive impact on inflation during the time studied. The signs of the coefficients match what we expected based on theory. The R-square from the estimates is around 73 percent, which means the model works well.

The error correction coefficient is negative and important, showing that there is a long-term connection between the variables. The error term has a value of -2.163624, which means that around 21% of last year's imbalances will be fixed this year.

4.4. Diagnostic Tests

4.4.1. Heteroskedasticity Test Results

We checked for Heteroskedasticity using the Autoregressive Conditional Heteroskedasticity (ARCH) test. The results of the White Heteroskedasticity test are shown in Table 6.

Table 6: Results of white heteroskedasticity test.

F-statistic	0.040456	Probability	0.841995
Obs*R-squared	0.043186	Probability	0.835375

The results in Table 6 show that the F-statistic is 0.040, and the probability value is 0.841. The R-squared value is 0.043, and the probability value is 0.835, which is higher than 0.05. This result shows that there is no sign of uneven spread of errors in the model.

4.4.2. Results of Serial Correlation Test

Test for autocorrelation was performed using Breusch-Godfrey Serial Correlation LM test. The results are presented in Table 7.

Table 7: Results of serial correlation LM test:

F-statistic	9.002445	Probability	0.001010
Obs*R-squared	13.20215	Probability	0.001359

The results of the Serial Correlation LM test show that the F-statistic is 9.002 and the R-squared value is 13.202. The chance of these values happening by chance is very low, with probabilities of 0.0010 and 0.0013. Since these probability values are higher than 0.05, we can say that there is no serial correlation in the estimates.

4.4.3. Results of Normality Test

The Jarque-Bera normality test was done to check if the leftover values in the model are normally distributed by using a histogram. The normality test results are shown in Figure 5.

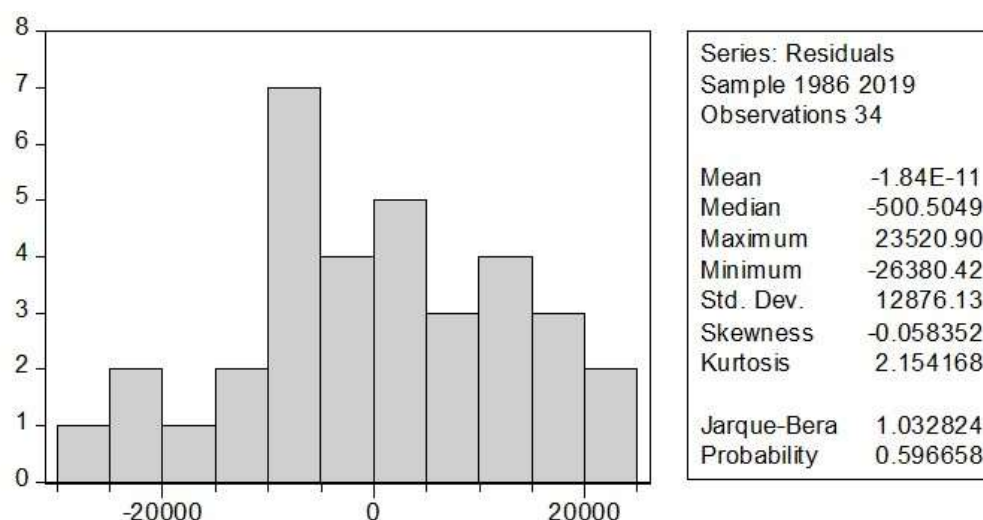
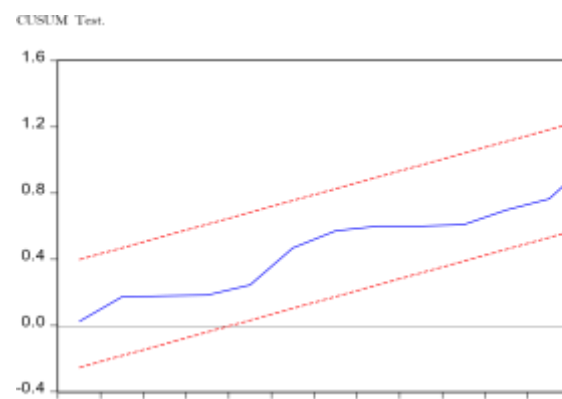
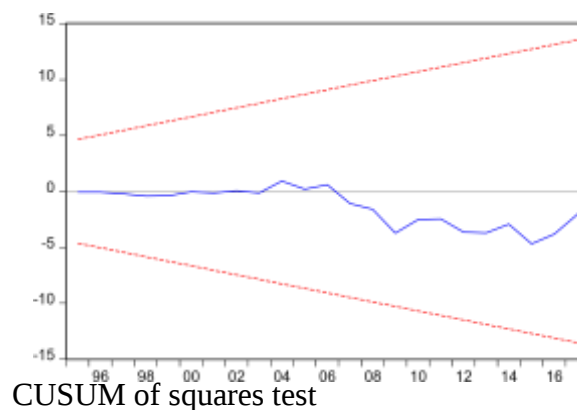


Figure 5: Results of jacrque-bera normality test.

The result of the normality test shows a probability value of 0.5966 which is greater than 0.05. This result indicates that the residual is normally distributed.

4.4.4. Results of Stability Test

To check how stable the model is, we used CUSUM and CUSUM of squares. The model is considered stable if its ongoing results stay within the two set limits. On the other hand, if the leftover values go beyond the two important lines, the model is considered unstable. The results of the stability test are shown in Figures 6a and 6b.



The results shown in Figures 2a and 2b suggest that both the CUSUM and CUSUM of squares graphs are stable. This is because the ongoing changes (recursive residuals) stay within the critical lines, which means they are all within the 5% limits. This means that the study's estimated values are consistent during the time it was looked at.

5. Conclusion and Recommendations

This paper looked at how changes in exchange rates affected inflation in Nigeria from 1986 to 2023. The results from the VECM showed that the money supply (MS) and the nominal exchange rate (NER) had a positive and important impact on the inflation rate in Nigeria during the time studied. This finding means that increasing the amount of money in Nigeria can lead to higher prices, or inflation. According to what we found, here are some suggestions:

- i. The Central Bank should control how much money is available in the economy. This is because when there is more money available, it usually causes prices to go up (inflation). To keep inflation in check, the CBN needs to keep an eye on how much money is in circulation.
- ii. The Central Bank should work harder to keep the exchange rate steady. A steady exchange rate keeps the prices of goods in the country stable. So, the CBN should keep the exchange rate steady by letting it be set by competition.
- iii. We need to cut down on importing too many goods. Inflation can come from countries where prices are going up. When the price of imported goods goes up, it can also affect the economy at home. These higher prices cause other local prices to go up and make the problem of inflation in the local economy worse.

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